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RESEARCH ON THE ECONOMICS OF TECHNOLOGICAL CHANGE IN AMERICAN AGRICULTURE*

VERNON W. RUTTAN
Purdue University

THROUGHOUT most of the world the major agricultural policy problem remains, as in the time of Malthus, how to speed the rate of growth of agricultural output and to relieve the "pressure of population on food supplies." In contrast, a major policy problem in American agriculture during the last three and a half decades has been how to deal with the problem of agricultural abundance—how to relieve the "pressure of food supplies on population."

In both situations technological change is commonly regarded as an important element in successful adjustment. In areas of heavy population pressure intensive efforts are being made to increase the rate of growth of farm output through the transfer of both specific agriculture techniques and a general body of scientific knowledge.[1] On the other hand, the very speed with which technological progress has occurred in American agriculture is commonly regarded as an important factor underlying both the income difficulties of commercial agriculture and the failure of the farm programs which have been developed to deal with these diffi-

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[1] See P. M. Raup, W. W. Cochrane and S. O. Berg, "The Role of American Agriculture in the World Economy," Discussion paper prepared for meeting of the Committee on Agricultural Economics of the Social Science Research Council, May 20-21, 1960.

culties.[2] As a result, administrators of agricultural research programs have increasingly been subject to criticism for the very success of their research efforts.[3]

Technological change has been described in many ways—in terms of individual changes in the techniques of production; by partial productivity measures such as changes in output per man hour, per acre, or per breeding unit; and by total productivity measures such as output per unit of total input.[4] Ideally, a definition of technological change should permit one to distinguish between the adoption of a previously unknown or unavailable production or organizational technique and the substitution of an existing technique for another. The definition should also be stated in general terms and not be tied to any one particular measurement technique. For analytical purposes it is convenient to use the term technology to refer to the body or stock of techniques, procedures, or ways of conducting economic activity. The level of technology can be conceptualized in terms of an aggregate production function whose parameters reflect all of the technical production possibilities currently available. Technological change can then be viewed as a change in one or more of the parameters of the aggregate production function resulting from the addition of new production techniques to the existing stock. Market conditions reflected through factor supply and demand schedules may cause firms, even in the same industry, to occupy different positions on this function and hence to employ different production techniques. Changes in the production techniques employed by individual firms may occur either as a result of shifts in the production function—from technological change—or as a result of changes reflected through factor and product markets.

Technological change, in the sense defined above, is usually preceded by scientific innovations and accompanied by organizational or social innovations. The nature of the processes by which such innovations are generated are but partially understood. And the manner in which economic resources can be brought to bear to alter the rate of scientific, technical and organizational innovation is even less well understood.[5]

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[2] This position has been vigorously developed by W. W. Cochrane in *Farm Prices—Myth and Reality*, Univ. of Minn. Press, Minneapolis, 1958. See particularly Chap. 5, "The Agricultural Treadmill," pp. 85-107.

[3] This criticism has usually taken the form of recommendations that "output increasing" innovations be contracted in favor of "input saving" innovations. See J. E. Coke in *Department of Agriculture Appropriations for 1955*, Hearings, Subcom. on Appropriations, U. S. House of Rep., 83rd Cong., 2nd Ses., Part 2, pp. 259-260.

[4] For a comprehensive presentation of developments in this area see the papers in J. W. Kendrick (Ed.), *Output, Input and Productivity Measurement* (Natl. Bur. Econ. Res. Studies in Income and Wealth, Vol. 25), Princeton Univ. Press (forthcoming).

[5] R. R. Nelson, "The Economics of Invention: A Survey of the Literature,"

The economic impact of technological change is felt first through its impact on the cost structure or the product mix of the individual firm in which new techniques are adopted; secondly through shifts in industry demand curves for factors of production and supply curves of final products;[6] and finally by the whole economy in terms of the effect of technological change on the rate of growth and distribution of total and per capita income (or leisure). Again the precise manner in which technological change interacts with institutional factors to produce structural changes, fluctuations in economic activity and economic growth is only incompletely understood and provides the basis for substantial professional debate.

Several research projects designed to increase understanding of the process of innovation and the impact of technological change in the agricultural sector of the economy and of the interrelationships between technological change in agriculture and in the rest of the economy are outlined below. These projects are arranged under three general headings: (a) the generation and introduction of new technology; (b) the contribution of technological change to economic growth; and (c) the interaction between technological change and economic organization.

The Generation and Introduction of New Technology

1. *The changing role of the land-grant university in the generation and introduction of new technology*

The agricultural colleges of the land-grant universities have traditionally occupied a multiple role with respect to technological change in agriculture.[7]

They have provided undergraduate and graduate instruction to students (a) who staff most of their own research and extension programs,

J. Business, 32:101-27, April 1959; V. W. Ruttan, "Usher and Schumpeter on Invention, Innovation and Technological Change," *Quar. J. Econ.*, 73:596-606, Nov. 1959.

[6] A comprehensive discussion of agricultural supply analysis is presented in Marc Nerlove and Kenneth L. Bachman, "The Analysis of Changes in Agricultural Supply," *J. Farm Econ.*, 42:531-54, Aug. 1960.

[7] For a history of the development of the resident instruction, extension and research programs at the land grant colleges and universities see A. C. True, *A History of Agricultural Extension Work in the United States, 1785-1923*, U. S. Dept. Agr. Misc. Pub. No. 15, 1928; A. C. True, *A History of Agricultural Education in the United States, 1785-1925*, U. S. Dept. Agr. Mis. Pub. No. 36, 1929; A. C. True, *A History of Agricultural Experimentation and Research in the United States, 1607-1925*, U. S. Dept. Agr. Mis. Pub. No. 251, 1937. A comprehensive discussion of developments in recent years is not available. Some insight into the changes that are occurring can be obtained from the discussions reported in the annual *Proceedings of the Association of Land-Grant Colleges and Universities*. See also C. M. Hardin, *Freedom in Agricultural Education*, Univ. of Chicago Press, 1955.

(b) who occupy an increasing number of the sales and research positions in the agricultural supply and processing industries, and (c) who operate or manage many of the higher-production commercial farms.

They have conducted, through the agricultural extension services, an adult education program designed to channel knowledge of scientific and technical information to farmers and to the agricultural supply and processing industries with the objectives (a) of speeding the rate of adoption of new techniques and (b) of encouraging the more efficient use of existing techniques.

They have conducted scientific and technical research with the objectives (a) of adding to the supply of basic scientific knowledge and (b) of developing new and/or improved techniques of direct usefulness in agricultural production and in the related supply and marketing industries.

In each of these areas casual observation suggests that substantial shifts from traditional patterns or functions are in process or are emerging.

Graduate instruction designed to provide professional and/or research training has expanded rapidly in most departments during the last decade and a half. Undergraduate enrollment on the other hand, has generally expanded slowly. In some fields it has actually declined.[8]

The adult education programs of the extension services are tending to emphasize the teaching of general principles to groups of farmers while placing less emphasis on providing specific answers to the production and management problems of individual farm operators. The latter functions are increasingly being provided by professional personnel in farm management firms and by field representatives, sales personnel and research workers in the agricultural supply and marketing industries. These groups in turn tend to work directly with experiment station research workers or college-based extension specialists.[9] The development of "farm and home planning" or "better farming and living" programs in recent years can be viewed as an attempt to reverse these trends. It seems clear that the trend can be successfully reversed only if rather massive resources are devoted to such efforts.

The research activities in the colleges of agriculture at many land grant universities appear to be placing increasing emphasis on the solution of problems which are defined within the framework of particular scientific disciplines. Emphasis is placed on the discovery of fundamental relation-

[8] C. F. Simmons, "Data and Trends in Agricultural Enrollment," *Proc. Amer. Assoc. Land-Grant Coll. and State Univ.*, Nov. 1957, pp. 194-197.

[9] For the implications of this development in the poultry science areas see J. H. Martin, "New Responsibilities in Extension Teaching," Paper presented at the 48th Annual meeting of the Poultry Science Assoc., August 6, 1959.

ships in such areas as genetics, nutrition, biochemistry and economics.[10] This is in contrast to earlier research activity which tended to be almost exclusively centered around the solution of specific problems of applied technology in areas such as plant or animal husbandry, food processing, or firm efficiency.

All of these tendencies appear to be mutually reinforced through the cumulative interaction of a more complex agricultural technology. Discovery of new scientific relationships provides the basis for new technical applications. These applications provide the basis for expanding agricultural supply and marketing industries. The growth of these industries results in the development of demands for scientifically trained research and sales staffs. The increasing technical and institutional complexity of the "agribusiness" complex creates a demand for more emphasis on general principles in the adult education program of the extension services and decreases the ability of limited extension staffs to deal adequately with the technical problems faced by individual firms. The growth of scientifically and technically staffed farm supply and marketing industries reduces the demand for technical services and increases the demand for applied research results and for knowledge of basic scientific relationships.

If the above impressions are correct they have important consequences for the future role of the colleges of agriculture in the generation and introduction of new technology.

It would seem desirable to attempt to ascertain: (a) the extent to which the tendencies outlined above have actually proceeded; (b) the implication of their continuation on the rate of generation and introduction of new technology; and (c) the implications of these tendencies for research and education in the colleges of agriculture.

More specifically: How far has the relative decline of research in the area of applied technology and the increased emphasis on scientific problem solving research actually proceeded? If the colleges of agriculture concede the dominant role in applied technical research and technical extension to the farm supply and processing industries, will this have a positive or negative impact on the effectiveness of the schools of agriculture in the area of basic scientific research and in undergraduate and graduate instruction? What will be the effect of less direct relationships between the colleges and farmers on the financial support for research

[10] This statement is based primarily on casual observation and discussion. The point has been made and the trend viewed with both approval and concern in discussion reported in the *Ann. Proc. Amer. Assoc. Land-Grant Coll. and Univ.* Here again the evidence appears to be based primarily on the casual observation of people who are participating in the indicated changes.

activities at the United States Department of Agriculture and at the colleges of agriculture in the several states? Will support for public appropriations weaken and the colleges become more dependent on grants from the farm supply and marketing industries?

2. *Interrelationships between technological change in agriculture and the structure of the farm supply industries*

The ratio of purchased inputs to total output has risen steadily over the last several decades in American agriculture.[11] The farm supply industries have played an important role in channeling technological advances into agriculture.[12] Adoption of new technology has usually increased agriculture's dependence on inputs produced in the nonfarm sectors of the economy and has lessened agriculture's dependence upon land inputs.

As farmers have become more conscious of the benefits of new technology, the lag between introduction and acceptance of new technology has tended to shorten. Farms and areas which have led in the adoption of new technology have expanded output relative to those who have been content merely to follow.[13]

The drive on the part of farmers to adopt new technology has placed a considerable premium on the ability of firms in the agricultural supply industries to provide this new technology. Although leadership in technological innovation is only one factor determining a firm's success, the decline of a number of supply firms, particularly in the farm equipment industry, has been attributed to failure to maintain the technological leadership on which the firm's earlier position in the industry had been based.[14] A real economic advantage occurs to the farm supply firm which can make its competitor's products obsolete.

An important characteristic of the expenditure of research funds in the farm supply industries, and in industry in general is that most of it is spent by large firms. Some writers attribute this to the fact that firms which produce diversified product lines are capable of utilizing in their own processes a larger share of the "uncertain" products of research ac-

[11] V. W. Ruttan, and T. T. Stout, "Regional Differences in Factor Shares in American Agriculture: 1925-57," *J. Farm Econ.*, 42:52-68, Feb. 1950.

[12] E. C. Young, "The Interaction Between Technical Change on the Farm and Technical Change in Marketing and Distribution," *Proc. Ninth Internatl. Conf. Agr. Economists*, 1956, pp. 157-67.

[13] T. T. Stout and V. W. Ruttan, "Regional Patterns of Technological Change in American Agriculture," *J. Farm Econ.*, 40:196-207, May 1958.

[14] Michael Conent, "Competition in the Farm Machinery Industry," *J. of Business*, 26:26-36, Jan. 1953; W. G. Phillips, *The Agricultural Implement Industry in Canada*, Univ. of Toronto Press, 1956, pp. 25-34, 159.

tivity.[15] Other writers, following Schumpeter, have stressed the circular interaction between monopoly (or oligopoly) profits and research expenditures.[16] Members of both groups have usually expressed concern lest the benefits of rapid technological change be offset by a decline in price competition as a result of industrial concentration.[17] A third group of students have questioned the general effectiveness and/or necessity of large scale industrial research organization.[18]

Organization for research and development in the farm supply industries varies widely. At one extreme are such industries as hybrid seed corn, where a substantial share of research and development has been conducted at USDA and land-grant college experiment stations.[19] At the other extreme is the farm equipment industry where public contributions have apparently been considerably smaller relative to the contributions by private industry.[20] A third variation is represented by the fertilizer industry where the TVA has provided what is in effect an industry research institute for the fertilizer industry with a research program ranging from fundamental chemical and biological research to applied engineering and economics.[21]

In view of the importance of the farm supply industries in the generation and introduction of new technology in agriculture it would seem worthwhile to attempt to answer the following questions: (a) What are the implications of market pressures in the farm supply industries for rapid development and introduction of new technology on the structure of the farm supply industries and on competition and pricing in the farm supply market? Can rapid technological change be regarded as an effective substitute for competitive structure? What pattern of industrial or-

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[15] R. R. Nelson, "The Simple Economics of Basic Scientific Research," *J. Pol. Econ.*, 67:297-306, June, 1959.

[16] J. A. Schumpeter, *Capitalism, Socialism and Democracy*, Harper and Brothers, New York, 1947, pp. 81-106; J. K. Galbraith, *American Capitalism*, Houghton Mifflin, Boston, 1952, pp. 84-94.

[17] Galbraith, *op. cit.*, pp. 135-153; W. J. Fellner, "The Influence of Market Structure on Technological Progress," *Quar. J. Econ.*, 65:556-77, Nov. 1951.

[18] H. H. Villard, "Competition, Oligopoly, and Research," *J. Pol. Econ.*, 66:483-97, Dec. 1958; Jacob Schmookler, "Bigness, Fewness, and Research," *J. Pol. Econ.*, 67:628-32, Dec. 1959; H. H. Villard, "Reply," *Ibid.*, pp. 633-35; W. F. Mueller, "A Case Study of Product Discovery and Innovation Costs," *Southern Econ. J.* 24:80-86, July 1957.

[19] Even in the case of hybrid corn, public expenditures have probably been less than half of total research expenditures. See Zvi Griliches, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *J. Pol. Econ.*, 66:419-31, Oct. 1958.

[20] This statement is based upon discussion with informed individuals in the field of agricultural engineering rather than on clear cut empirical evidence.

[21] J. W. Markham, *The Fertilizer Industry*, Vanderbilt Univ. Press, Nashville, 1958, particularly pp. 209-238.

ganization is most conducive to technical and scientific innovations? (b) What are the implications of greater industry research and development efforts for publicly-supported research? More specifically, how does it influence the balance between applied technical research and basic scientific research at academic institutions? Can public research and development programs be used to counter any adverse effects of a less competitive structure in the farm supply industries?

3. *The introduction of new technology*

Both economists and sociologists are employing relatively well-defined but quite dissimilar approaches in studying the introduction of new technology.

Sociologists have placed their main emphasis on the development of models of the "diffusion process" to explain how new techniques developed or adopted by innovators spread to other members of the community.[22] The model employed by the sociologists has a positive rather than a normative function.[23] It contains no elements which permit the student to sort out those innovations which will be successful (i.e., profitable) from those which will not be successful. For those innovations which are profitable the model does predict the sequence in which the innovation will be accepted by different socio-economic groups within the community and it identifies the sources of information which are most effective in reaching each group.

Economists have discussed the problem of introduction of new technology largely within the framework of capital theory—particularly that part of capital theory which in recent years has been designated as replacement theory.[24] The model employed by economists is primarily

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[22] Coleman, A. L., C. R. Hoffer, H. F. Lionberger, H. A. Pederson, Neal Gross and E. A. Wilkening, *Sociological Research in the Diffusion and Adoption of New Farm Practices*, (Rept. of Subcom. on the Diffusion and Adoption of Farm Practices of the Rural Sociological Soc.) Ky. Agr. Expt. Sta., June 1952; Rogers, Everett M., and George Beal, *Reference Group Influences in the Adoption of Agricultural Technology*, Dept. Econ. and Sociology, Iowa State College, Ames, 1958. For an application of the "diffusion" approach to industrial situations see Edwin Mansfield, "Technological Change and the Imitation Process," paper presented at Winter meeting of Econometric Soc., Washington, Dec. 1959.

[23] These terms are used here in the sense usual in economics literature: a "positive" model (or theory) deals only with the empirical consequences of specific actions a "normative" model (or theory) specifies the decision or action that should be taken under specific conditions. This use of "normative" should not be confused with the sociologists' concept of "social norm," which refers to a behavior standard.

[24] For a review and extension of recent work see V. L. Smith, "The Theory of Investment and Production," *Quart. J. Econ.*, 73:61-87, Feb. 1959. Smith gives particular attention to the work of Fredrich and Vera Lutz, *The Theory of Investment at the Firm*, Princeton Univ. Press, 1951, and George Terborgh, *Dynamic Equipment Policy*, McGraw-Hill, New York, 1949.

normative in orientation. The objective is to specify when an existing piece of capital equipment "should" be replaced by a new piece of capital equipment or a new process if profits are to be maximized.

Both approaches are clearly incomplete and both have several limitations even within the framework in which they have been formulated. The developers of diffusion models have tended to approach the problem of model construction through strictly empirical techniques designed to identify factors associated with diffusion. They have tended to accept the socio-economic structures of the community as given and to concentrate on educational methods designed to speed the rate of diffusion through the given structures. Almost no attention has been given to the policy measures, such as investment in education, which might be used to modify the socio-economic structure of the community in a way that would speed the rate of diffusion. Little attempt has been made to incorporate behavior theory into their models. Consequently, the empirical generalizations which have been made have only limited application to situations other than those actually studied.

The economic model is fully developed only for conditions of perfect competition. When risk and uncertainty and/or imperfect competition are introduced, the model becomes so complex that useful solutions become difficult.

Research on the introduction of new technology should concentrate on three problems: (a) elaboration of current diffusion models to take into account the effects of induced changes in the socio-economic structure of the community and to incorporate the findings of behavior theory; (b) further development of the economic models to more effectively incorporate imperfect competition and uncertainty assumptions; (c) the development of socio-economic models which incorporate the normative features of the economic models and the positive features of the sociological models. Work along the first two lines is currently being implemented. Little or no attention is being given to the development of socio-economic models. Work in this area deserves more attention currently. It should not be held in abeyance until the sociological and economic models have been perfected.

The Contribution of Technological Change to Economic Growth

4. *Conceptual problems in measuring the impact of technological change*

Although technological change has traditionally been defined in terms of changes in the parameters of a production function or the creation of new production functions, empirical attempts to measure technological change have typically focused on the problem of identifying the contribution of technological change to output or to resource utilization. Two

general approaches have generally been employed in attempts to measure the output (or resource) impacts of technological change. The traditional procedure has been to use a partial productivity index, (e.g., average output per unit of labor or capital input) or a total productivity index (output per unit of total input) as a measure of the impact of technological change.[25] More recently a production function approach has been used. Comparisons are typically made between the level of output that would have been produced using the current level of inputs with the production function of some base period and the level of output obtained with the same inputs currently. The increase in the current level of output over the level projected from the base period production function is then attributed to technological change.[26]

A major problem which has not been solved by users of either approach is how to separate the effect of changes in technology from other factors which change the level of output obtained from a given level of total input. With either approach bias may be introduced: (a) if the firm, industry, or economy is not operating at equilibrium in both periods; (b) if the prices of factors relative to each other and/or the prices of products relative to each other do not remain unchanged; (c) if constant returns to scale do not hold; and (d) if technological change is non-neutral.[27]

A second problem which has faced research workers is the question of just what should go into the output and input measures. Researchers who

[25] The total productivity approach was suggested as early as 1938 in M. L. Copeland and E. M. Martin, "The Correction of Wealth and Income Estimates for Price Changes," *Conference on Research in National Income and Wealth*, Vol. II, Natl. Bu. Econ. Res., Inc., New York, 1938, pp. 85-119. The earliest application of the total productivity approach to the measurement of technological change at the national level with which I am familiar was by George J. Stigler, *Trends in Output and Employment*, Natl. Bu. Econ. Res., Inc., New York 1947, pp. 43-45. The first application in Agriculture was by Glen T. Barton and Martin R. Cooper, "Relation of Agricultural Production to Inputs," *Rev. Econ. and Stat.*, 30:117-26, May 1948. For a comprehensive discussion of methodology and measurement problems see J. W. Kendrick (Ed.), *Output, Input and Productivity Measurement, op. cit.*, and J. W. Kendrick, *Productivity Trends in the United States*, Princeton Univ. Press (forthcoming).

[26] R. M. Solow, "Technical Change and the Aggregate Production Function," *Rev. Econ. and Stat.*, 39:317-20, Aug. 1957; V. W. Ruttan, "The Contribution of Technological Change to Farm Output, 1950-75," *Rev. Econ. and Stat.*, 38:64-69, Feb. 1956. For a criticism of the production function approach see L. L. Pasinetti, "On Concepts and Measures of Changes in Productivity," *Rev. Econ. and Stat.*, 41:270-82, Aug. 1959.

[27] G. W. Ladd, "Biases in Certain Production Indexes," *J. Farm Econ.*, 39:75-85, Feb. 1957; V. W. Ruttan, *Technological Change in the Meat Packing Industry, 1919-47*, USDA, Agr. Mktg. Res. Rep. No. 59, Jan. 1954, pp. 15-28; G. J. Stigler, "Economic Problems in Measuring Changes in Productivity" in J. W. Kendrick (Ed.), *Output, Input and Productivity Measurement, op. cit.*

have placed primary emphasis on measuring technological change in the agricultural sector have usually measured output in terms of the total value of farm products produced.[28] Where the major interest has been to construct inter-industry or inter-regional comparisons or national indices of technological change, output has usually been measured in terms of value added, while current operating expenses have been omitted on the input side in an attempt to eliminate double counting.[29] The second procedure is more consistent than the first with national income accounting procedures. It may, however, result in under- or over-estimating a particular industry's contribution to technological change, even though it correctly identifies the resource savings which have occurred in a particular industry. It seems likely, for example, that a major effect of technological change in the fertilizer industry is to produce input savings in the agricultural sector.[30] This is partially taken into account when fertilizer inputs are excluded from the input side and are subtracted (along with other current operating expenses) from the output side. Bias may be introduced, however, if the marginal productivity of some inputs exceeds and of others fails to equal input prices.

Increasing attention has also been given to the question of whether inputs of social capital and changes in the quality of inputs are being correctly incorporated into the technological change calculations. Schultz has argued that public expenditures on education have substantially improved the quality of the agricultural labor force and that these public inputs have been typically omitted in conventional labor input measures.[31] He suggests, in effect, that productivity gains currently attributed to technological change should be allocated between (a) changes in the quality of labor and (b) changes in the quality of capital. Only those

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[28] See, for example, W. D. Goodsell, "Costs and Returns on Commercial Family Operated Farms by Type, Size and Location," in *Major Statistical Series of the U. S. Department of Agriculture, Vol. 3, Gross and Net Farm Income,* USDA Agr. HB. No. 118, 1957, p. 89. See also the annual USDA reports on *Farm Costs and Returns.*

[29] T. T. Stout and V. W. Ruttan, "Regional Patterns of Technological Change in American Agriculture," *op. cit.,* pp. 199, 201.

[30] Zvi Griliches, "The Demand for Fertilizer: An Economic Interpretation of Technical Change," *J. Farm Econ.,* 40:591-606, Aug. 1959.

[31] T. W. Schultz, "Reflections on Agricultural Production, Output, and Supply," *J. Farm Econ.,* 38:748-62, August 1956. For discussion of this paper see E. O. Heady, "Output in Relation to Input for the Agricultural Industry," *ibid.,* 40:393-405, May 1958; T. W. Schultz, "Output-Input Relationships Revisited," *ibid.,* 40:924-31, Nov. 1958; E. O. Heady, "On Output-Input Relationships Revisited: A Reply," *ibid.,* 41:134-36, Feb. 1959. See also T. W Schultz, "Investment in Man: An Economist's View," *The Social Service Rev.,* 33:109-17, June 1959; and A. G. Frank, "Human Capital and Economic Growth," *Economic Development and Cultural Change,* 7:170-73, Jan. 1960.

gains which can be attributed to changes in the quality of capital would then be identified as resulting from technological change. If an attempt is to be made to allocate total productivity gains between changes in labor quality and changes in the quality of capital, techniques will have to be developed which permit an independent measure of at least one of the two elements.

The problems discussed above are based both on limitations in the models employed to measure the impact of technological change on resource utilization and output growth and on defects in the data used. These models (a) have employed extremely simplified concepts of interindustry relationships and (b) have attempted to use partial equilibrium techniques to measure changes in a dynamic growth process.

Furthermore, little attention has been given in studies of technological change to the kinds of information that would be most useful in the analysis of agricultural supply response. One is struck by the fact that in the analysis of short-run supply response strong emphasis is typically given to the role of price and little or no attention to the role of technological change. In the analysis of long-run supply response, on the other hand, major attention is typically focused on the rate of technological change with little or no attention to the role of price behavior.[32] Until the empirical and conceptual limitations discussed above are overcome empirical measures of technological change must be considered as highly provisional and their use in supply analysis will be limited.

5. *Case studies of the economic impact of specific innovations*

Both in agriculture and in other areas a substantial share of total research expenditures are financed directly or indirectly from public sources. The total level of such expenditures has expanded rapidly in the last decade and a half.[33] General recognition that research, particularly basic research, generates substantial externl economies would seem to assure continued expansion of publicity supported research.

As total research appropriations expand, however, increasing effort will be devoted to an examination of the relative social benefits resulting from research along alternative lines. Agriculture, along with other claimants, will have to justify requests for research funds in terms of the po-

[32] See the discussion in Marc Nerlove and Kenneth L. Bachman, "The Analysis of Changes in Agricultural Supply," *loc. cit.*

[33] See for example the several studies by the National Science Foundation. These reports are listed in "Bibliography on the Economic and Social Implications of Scientific Research and Development," U. S. Govt. Print. Off., Washington, 1959, pp. 19, 20 (NSF 39-41). See also "The Role of Research on the Economics of Universities," C. C. Fumas and Raymond Ewell, in Dexter M. Keezer (Ed.) *Financing Higher Education, 1960-70*, McGraw-Hill, New York, 1959, pp. 79-102.

tential contribution of such funds to national welfare. Attempts to answer questions cast in this framework will require a good deal more precision than the statements we are currently able to make with respect to total resource savings due to technological change.

A good deal of experience has already been accumulated in evaluating the output effects of specific innovations or lines of innovation.[34] Furthermore, this experience seems to be resulting in greater accuracy in projecting the output effects of agricultural innovations. The next step in this analysis should be to analyze the relationships between research expenditures, output growth and net social returns for specific innovations. The excellent studies of research costs and social returns from hybrid corn by Griliches[35] and of labor-saving technology in sugar beets by Mamer[36] should be supplemented by other case studies in the areas of mechanization, animal nutrition and others.

Interaction Between Technological Change and Economic Organization

6. *The impact of technological changes on product market organization*

A market or marketing system can be viewed, in part, as a device for coordinating production and consumption decisions at various levels.[37] In traditional commodity markets this coordination has been achieved primarily by the transfer of information summarized in the form of price and quantity data.

Even if such a system resulted in accurate and near-instantaneous transfer of information, substantial resources would have to be devoted to summarizing and condensing the multiplicity of available information into price and quantity terms and to the transmission of this information throughout the system. The necessity of condensing many diverse types of information into price and quantity terms results in substantial loss of relevant information and hence limits the degree of coordination possi-

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[34] Land-Grant Colleges–Department of Agriculture Joint Committee on Agricultural Productive Capacity, *Agricultures Capacity to Produce: Possibilities Under Specified Conditions,* U. S. Dept. Agr. Inf. Bul. No. 88, 1952; H. F. Breimyer, "Sources of Our Increasing Food Supply," *J. Farm Econ.,* 30:228-42, May 1954; J. D. Black and J. T. Bonnen, *A Balanced United States Agriculture in 1965,* Natl. Planning Assoc., Washington, Spec. Rept. No. 42 (undated).

[35] Zvi Griliches, "Hybrid Corn, An Exploration in the Economics of Technological Change," *Econometrica,* 25:501-22, Oct. 1957; also, "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *loc. cit.*

[36] Mamer, J. W. "The Generation and Proliferation of Agricultural Hand-Labor-Saving Technology: A Case Study of Sugar Beets" (Unpub. Ph.D. thesis, Univ. of Calif., Berkeley, Jan. 1958).

[37] Wroe Alderson, *Marketing Behavior and Executive Action,* Irwin, Homewood, 1957, pp. 40-51, 77; R. L. Meier, "Information, Resources Use and Economic Growth," Paper presented at the Conf. on Natural Resources and Economic Growth, Univ. of Mich., Ann Arbor, April 7-9, 1960.

ble under traditional patterns of market organization. Devices such as hedging, diversification, and overcapacity of production, processing, and storage facilities can, in part, be regarded as costs incurred as a result of the risk and uncertainty resulting from inadequate coordination of decisions at the various levels of the marketing system.[38]

In spite of the limitations of traditional commodity market organizations they were apparently the most effective method of coordination available in a system composed of relatively small producer, processor and distribution agencies. Indeed, such systems were substantial improvements over the rather complete lack of coordination that would have existed in their absence. And without the technological changes in transportation and communication that took place in the 19th century it would have been difficult for them to develop as effective marketing institutions. It was not entirely accidental that the Chicago Board of Trade was organized the same year that the first telegraph arrived in Chicago.[39]

Technological change has acted to alter the traditional market organization in at least two major ways.

First, technological change has multipled (a) the amount and variety of information relevant for decision making, as the raw material requirements for the several uses of a product become more specific (e.g., the differentiation of potatoes for boiling, baking, chipping, or making french fries);[40] (b) the possibilities and advantages of direct control over quality at the production level to match requirements at later stages. The technical possibility of controlling quality at the production level, for example, opens up the possibility of eliminating sorting, a major marketing activity, as the product passes through marketing channels.[41]

Second, technological and organizational innovations have permitted the organizations of production of many agricultural commodities and the distribution of food products into substantially larger units than was formerly considered feasible.[42] Changes in transportation have decreased

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[38] S. A. Reiter, "Some Considerations Affecting the Analysis of Economic Organization," Tech. Rept. #7, Dept. of Econ., Stanford Univ., March 23, 1953.

[39] J. S. Schonberg, *The Grain Trade,* Exposition Press, New York, 1956, p. 13.

[40] For discussion of an interesting example see *The Commercial Potato Peeling Industry: A Survey,* USDA, Mktg. Res. Rept. No. 105, 1955.

[41] W. F. Mueller and N. R. Collins, "Grower-Processor Integration in Fruit and Vegetable Marketing," *J. Farm Econ.,* 39:1471-85, Dec. 1955. Also J. A. Seagraves and C. E. Bishop, "Impact of Integration on Output, Price and Industry Structure," *J. Farm Econ.,* 40:1814-24, Dec. 1958.

[42] G. L. Mehren, "Marketing Coordination and Buyers Requirements," in *Policy for Commercial Agriculture,* Subcom. on Agricultural Policy, Joint Economic Comm., 85th Cong., 1st Sess., Nov. 1957.

the necessity for commodities to pass through terminal marketing centers where traditional marketing agencies have been located.[43]

As a result of these changes, pressures for the development of alternative methods of coordinating production, marketing, and consumption decisions have been generated. The most dramatic example of the emergence of a new form of coordination is provided by the growth of integration in the broiler industry. It seems likely that integration is only one potential response that may be generated by the new technical and organizational possibilities. In the fluid milk industry alternative methods of coordination have been developed through the marketing order device.

Rather than waiting until new market forms have emerged and solidified before economic analysis is undertaken, it would seem desirable to attempt to anticipate new forms of market organization which would make most efficient use of the emerging technical and organizational possibilities, and to assess their welfare implications for agriculture and for other segments of society. The challenge is for economists and other social scientists to use their technical skills and creativity to speed the rate of organizational (or social) innovations.

7. *Interaction between technological change and agricultural policy*

Governmental intervention in production and marketing is an integral part of the structure of American agriculture. The measures introduced to achieve agricultural policy objectives have direct implications for the rate of adoption of new technology or at least for the degree of intensity to which new techniques are carried. And the rate at which new technology becomes available and is adopted has definite implications for the effectiveness of agricultural policy.[44]

During the last half century society has committed a large and expanding quantity of resources to agricultural research and education. The stated objective of this research has usually been to lower farmers' production costs and thus assure higher incomes in agriculture rather than to provide lower cost food and fiber to the nonfarm population, although the latter objective has certainly occupied a position of some importance, particularly in those policies and programs which have been oriented to conservation objectives. Innovations designed to lower costs, however,

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[43] R. W. March and L. F. Herrmann, *The Establishment of Central Market Butter Prices in Chicago and New York*, USDA Mktg. Res. Rept. No. 53, 1953; N. T. Pritchard and O. J. Gerald, "Pricing Eggs at Wholesale in New York City, *Agr. Econ. Res.*, Oct. 1956, pp. 109-118.

[44] W. W. Cochrane, "The Blind Policy Alleys," Chap. 6 in *Farm Prices: Myth and Reality*, Univ. of Minn. Press, 1958, pp. 134-157.

have a curious propensity to result in expanded output. Indeed it is difficult to conceive of an innovation that successfully lowers costs which does not also expand output (and hence lower prices) under free market conditions.[45] While the early adoptors of new techniques may experience income gains relative to other farmers and nonfarm workers the welfare effects of either a rise or a decline in the rate of technological change on farmers as a group is not clear. An empirical answer would require an intricate balancing of opposing short- and long-run effects plus a solution to the problem of weighing welfare gains and losses by different members of the farm population.

The impact of new knowledge flowing into agriculture had, by the mid 1920's, reached such proportions that substantial increases in farm output were being achieved with only moderate increase in capital inputs and with constantly declining labor inputs.[46] Technological change was permitting agriculture to meet the nation's food and fiber requirements at lower (relative) prices but the output effects of the new technology were resulting in substantial changes in the organization of agricultural production[47] and were placing increasing downward pressure on total net farm income.[48]

The farm policy discussions of the late 1920's and the farm price programs instituted since the mid 1930's can be viewed, from today's perspective, as attempts to design institutional structures which would capture a larger share of the social gains from new technology for the agricultural sector of the economy. The fact that the problem was not cast in this framework, however, has resulted in programs designed to meet supposedly temporary emergencies rather than to meet the continuing pressure which new technology has and will continue to exert on farm prices and incomes. Indeed, to the extent that these programs have been successful in raising or stabilizing prices they have probably speeded the in-

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[45] E. O. Heady, "Basic Economic and Welfare Aspects of Farm Technological Advance," *J. Farm Econ.*, 31:293-316, May 1949.

[46] T. W. Schultz, "Gauging the New and Better Production Possibilities," Chap. 7 in *The Economic Organization of Agriculture*, McGraw-Hill, New York, 1953, pp. 99-124; W. W. Cochrane, "Conceptualizing the Supply Relation in Agriculture," *J. Farm Econ.*, 36:1161-76, Dec. 1955; G. T. Barton and M. R. Cooper, "Relation of Agricultural Production to Inputs," *op. cit.*

[47] For an excellent discussion of the impact of technology on the organization of farm production at the firm level see J. M. Brewster, "The Machine Process in Agriculture and Industry," *J. Farm Econ.*, 32:69-81, Feb. 1950. (Brewster does not deal with the tendency for certain activities such as fuel production and many semi-processing activities—*e.g.* farm separation of cream—to be shifted from the farm to the non farm sector.)

[48] W. W. Cochrane, "The Agricultural Treadmill, Chap. 5 in *Farm Prices: Myth and Reality, op. cit.*, pp. 85-106.

troduction of new technology and hence helped to assure that the problems they were set up to deal with could not remain temporary.[49]

When the price and income problems of commercial agriculture are considered within the above framework, several questions are posed to economists interested in agricultural policy:

(a) What has been the impact of technological change on the personal distribution of income within agriculture—as among operators of large-scale, commercial farms, medium or family-scale farmers, regular hired farm workers, and migrant workers?

(b) Can programs be designed which encourage technological change in agriculture and at the same time slow the transfer of savings from technological change from farmers to the consumers of food and fiber sufficiently to ease the downward pressure on farm incomes? Can these programs be designed in such a way that their effect on farm income is not regressive? Or does technological change make any program designed to affect agricultural prices an ineffective tool for the achievement of income goals?

(c) Is there an optimum rate of technological change in the agricultural sector from the point of view of either national economic growth or the welfare of the farm population? The question carries the implication that there is some upper level to the support which society should provide to the agricultural research "industry." This level may be at the point where the incremental cost of "adjustment" equals the incremental benefits from public research and extension expenditures.

8. *The impact of technological change on interregional competition*

It seems clear that lag in the adoption of new technology has been an important factor in the failure of some farmers and some regions to maintain or strengthen their position in American agriculture.[50] Traditionally important roles have been assigned to (a) regional differences in resource endowments, (b) variations in the rate of growth of total and per capita agricultural income, and (c) shifts in product demand. In recent years increased attention has been given to (d) the impact of differences in the rate of urban industrial development on agricultural income.[51]

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[49] R. W. Grey, V. L. Sorenson and W. W. Cochrane, *An Economic Analysis of the Impact of Government Programs on the Potato Industry of the United States,* Univ. of Minn. Agr. Exp. Sta. Tech. Bul. 211, June 1954, pp. 118-123; G. L. Johnson, *Burley Tobacco Control Programs,* Ky. Agr. Exp. Sta. Bul. 580, Feb. 1952, pp. 53-56.

[50] T. T. Stout and V. W. Ruttan, "Regional Patterns of Technological Change in American Agriculture," *op. cit.,* pp. 200-07.

[51] See Chap. 8, "Divergencies in Economic Development Related to Location," and Chap. 9, "Income Disparity Among Communities and Economic Development," in T. W. Schultz, *The Economic Organization of Agriculture,* pp. 146-71. For tests

Empirical studies which have focused on the role of technological change in interregional competition are almost nonexistant. The potential impact is, however, occasionally noted in the form of assertions to the effect that: (a) the new technology of the last several decades has been, on balance, more favorable to output expansion in the North Central region than in the South; (b) the development of hybrid sorghums will tend to encourage the development of a livestock feed economy in the Southwest; (c) lag in labor productivity in milk production is producing new low-income areas in parts of the Lake States and the Northeast.

Any complete analysis of the regional impact of technological change on location of agricultural production must consider the effects of technological changes in processing and distribution as well as technological changes at the farm level. Technological change in the fertilizer industry—particularly high analysis nitrogen fertilizer—has probably favored output expansion in the Midwest relative to the South. Development of low-cost milk concentrates that meet consumer acceptability requirements will probably favor milk producers in Wisconsin and Minnesota relative to milk producers elsewhere.[52] And the particular association of technological and institutional innovations which has characterized the development of the broiler industry has clearly favored expansion in the South in contrast to the traditional broiler producing regions.[53]

The importance of achieving a better understanding of the role which technological change has played and can play in bringing about regional differences in the rate of growth of total and per capita income in agriculture is particularly important since the rate of technological change may be more subject to the impact of public policy than regional differences in resource endowments, regional shifts in demand, or regional differences in urban-industrial development.

9. *The transferability of new technology among industries, regions and countries*

If technological change has been an important factor in accounting for growth differences among agricultural regions it would seem pertinent

of the Schultz urban impact hypothesis see V. W. Ruttan, "The Impact of Urban-Industrial Development on Agriculture in the Tennessee Valley and the Southeast," *J. Farm Econ.*, 37:38-56, Feb. 1955, and A. M. Tang, *Economic Development in the Southern Piedmont: Its Impact on Agriculture, 1860-1950*, Univ. of N. C. Press, 1958. For criticism of the Schultz position see Rutledge Vining, "On Describing The Structure and Development of a Human Population Sytem," *J. Farm Econ.*, 41:922-42, Dec. 1959, and D. C. North, "Agriculture in Regional Economic Growth," *J. Farm Econ.*, 41:943-51, Dec. 1959.

[52] M. M. Snodgrass and C. E. French, *Linear Programming Approach to the Study of Interregional Competition in Dairying*, Purdue Agr. Expt. Sta., Bul. 637, 1958.

[53] W. R. Hering, "Broiler Production Regions of the Future," *J. Farm Econ.*, 39:1188-98, Dec. 1957.

to ask why some regions have been relatively favored by new technology. In general agricultural research expenditures per capita of farm population has varied more widely among states than expenditures for the extension of agriculture information to farmers. The heaviest expenditures for research per capita of farm population have generally been in the major industrial states, where income from nonagricultural sources is relatively large compared to agricultural incomes, thus providing a strong tax basis for the support of public institutions.[54] The areas in which research expenditures have been highest have also experienced the most rapid rates of technological change in agriculture.[55]

The possibility of substantial lags in the adoption of new technology among regions within the agricultural sector would seem to imply the probability of even greater lags in the application of new technology among industries. The tendency for technical application of scientific innovations to achieve a rather high level of development in some industries before more than rudimentary progress has been made in other industries has frequently been noted.[56] The emergence of major innovations at widely separated time periods and their gradual diffusion throughout industry was employed by Schumpeter as an explanation for long (60 year) cycles of economic activity.[57]

Do these observations imply relatively limited transferability of research results or inadequate institutional arrangements to stimulate such transfers? This question is of particular importance because of the emphasis which is placed on achieving rapid technological progress in the agricultural and nonagricultural sectors in most underdeveloped countries and the important role which American agriculture research and extension personnel are playing in organizing agricultural research and extension work in such countries.[58] The literature dealing with such pro-

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[54] T. W. Schultz, "Agriculture and the Application of Knowledge," in *A Look to the Future*, Proc. of Conf. at W. K. Kellogg Found., Battle Creek, Mich., June 1956, pp. 54-78.

[55] Compare, for example, the regional distribution of research expenditures in T. W. Schultz, *ibid.*, with the regional differences in the rate of technological change presented in Stout and Ruttan, *op. cit.*, p. 201.

[56] See, for example, E. D. Ross, "Retardation in Farm Technology Before the Power Age," *Agr. History*, 30:11-18, Jan. 1956.

[57] J. A. Schumpeter, *Business Cycles*, McGraw-Hill, 1939, Vol. I, pp. 161-74. For another approach which emphasizes "technological determinism" see H. J. Burton, "Innovations and Equilibrium Growth," *Econ. J.*, 66:455-66, Sept. 1956. Other students have argued that the impact runs in the opposite direction—that business fluctuations have been a major factor affecting the rate of adoption of innovations. The two positions need not, however, be mutually inconsistent.

[58] For an interesting case study see Lawrence Witt, "Corn Farming in Brazil," Harvard Bus. School EA-R 157, 1953, and "International Basic Economy Corporation Hybrid Seed Operation in Brazil," Harvard Bus. School EA-R 156, 1953.

grams has given considerable attention to the training and extension aspects of technical assistance.[59] Little attention is given to the question of the extent to which technical assistance programs should focus on interregional and/or international transfers of technical information relative to the development of research institutions which produce technical information relevant to local problems "on site."[60]

Summary and Conclusions

In the first two sections of this paper the major emphasis has been on outlining research designed to improve understanding of forces leading to technological changes in American agriculture and to measure the impact of technological change on resource utilization. In the last section the problems outlined are primarily of a type which call for the economist and other social scientists to employ their skills and creativity to use new technology to bring about socially desirable adjustments. The alternative is for society to simply adjust to, rather than make effective use of, new technological and organizational possibilities.

All of the areas of research activity outlined in this paper are important. My own inclination would be, however, to place highest priority on six areas—the first four plus the sixth and seventh. The first two areas deal with the effectiveness of the institutional structures which are responsible for the generation and introduction of new technology in the agricultural sector. The third and fourth deal with the effectiveness of the analytical tools used in dealing with technological change at the micro and macro levels. The sixth and seventh emphasize public policy problems resulting from technological change in agriculture. These last two are also the areas where social innovation is most urgently needed.

[59] See, for example, the paper by Mordecai Ezekiel, "Ten Years of FAO Statistics and Economic Training Centers," *J. Farm Econ.*, 39:221-23, May 1957, and comment by E. C. Young, "Discussion," *ibid.*, pp. 249-60.

[60] For an exception see the discussion by J. G. Harrar, "International Collaboration in Food Production," Address before the Agr. Res. Inst., Natl. Acad. of Sci.—Natl. Res. Coun., Washington, D.C., Oct. 4, 1954.

ANALYTICAL TECHNIQUES USED IN DETERMINING THE OPTIMUM REPLACEMENT PATTERN*

J. Edwin Faris**
University of California, Davis

THE purpose of this paper is to present appropriate techniques to use in determining when to replace certain types of assets. The problem will be approached in terms of maximizing revenue over time.[1] The concepts involved are developed first for a relatively simple problem of replacement as a basis for the more complex models that follow. Three different types of enterprises will be used to illustrate the basic procedures involved in determining the optimum replacement pattern.

A Short Production Period with Revenue Being Realized by the Sale of the Asset

The simplest type of replacement problem is one that is concerned with a short production period and with the returns being obtained only by the sale of the asset. A dry-lot cattle finishing operation is a good example of this type of enterprise. The feedlot operator is faced with the problem of when to sell each lot of cattle and replace them with another lot.

Maximizing net revenue

In a continuous operation, in which each lot of cattle is replaced immediately by a new lot, the operator is concerned with maximizing his *average net revenue over time.* To illustrate the problem, a simplified numerical example is presented (Table 1). It assumes that the operator expects to be able to buy and sell feeder cattle at 20 cents a pound. Costs include initial purchase price for a 600-pound animal plus feed costs (other costs are assumed constant over time). Both costs and returns are based on actual physical input-output relationships. No account is taken of changes in quality of animal with length of feeding period. Table 1 shows costs and returns by ten-day feeding periods; footnotes show the algebraic functions from which the data were calculated. The net revenue function is shown graphically in Figure 1.

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** The author is indebted to H. Russell Shaw, Gordon A. King and Sidney Hoos for their helpful suggestions during the development of this paper.

[1] H. R. Shaw of the University of California at Davis is presently investigating the optimum replacement of equipment in terms of minimizing costs. In Dr. Shaw's investigation the total revenue is assumed to remain constant but certain costs, e.g., depreciation, vary with use. In this paper the physical inputs and their related costs are specified and total revenue varies over time.

TABLE 1. COSTS AND RETURNS FOR FEEDER CATTLE

Ten Day Feeding Period (n)	Total Cost[a]	Total Revenue[b]	Net Revenue[c]	Marginal Cost[d]	Marginal Revenue[e]	Marginal Net Revenue[f]	Average Net Revenue[g]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	$120.00	$120.00	$ 0	$2.00	$ 0	$−2.00	$ 0
1	122.01	120.58	−1.43	2.02	1.14	−.88	−1.43
2	124.05	122.24	−1.81	2.08	2.16	.08	−.90
3	126.18	124.86	−1.32	2.18	3.06	.88	−.44
4	128.43	128.32	−.11	2.32	3.84	1.52	−.03
5	130.84	132.50	1.66	2.50	4.50	2.00	.33
6	133.45	137.28	3.83	2.72	5.04	2.32	.64
7	136.30	142.54	6.24	2.98	5.46	2.48	.89
8	139.43	148.16	8.73	3.28	5.76	2.48	1.09
9	142.88	154.02	11.14	3.62	5.94	2.32	1.24
10	146.70	160.00	13.30	4.00	6.00	2.00	1.33
11	150.92	165.98	15.06	4.42	5.94	1.52	1.37
11.2	151.81	167.17	15.36	4.51	5.91	*1.40*	*1.37*
12	155.58	171.84	16.26	4.88	5.76	.88	1.36
13	160.72	177.46	16.74	5.38	5.46	.08	1.29
13.1	161.26	178.00	*16.74*	*5.43*	*5.43*	0	1.28
14	166.39	182.72	16.33	5.92	5.04	−.88	1.17
15	172.61	187.50	14.89	6.50	4.50	−2.00	.99
16	179.44	191.68	12.24	7.12	3.84	−3.28	.76

[a] $TC=120+2.0n+.0067n^3$

[b] $TR=120+.6n^2-.02n^3$

[c] $NR=TR-TC=-2.0n+.6n^2-.0267n^3$

[d] $MC=\frac{dTC}{dn}=2.0+.02n^2$

[e] $MR=\frac{dTR}{dn}=1.2n-.06n^2$

[f] $MNR=MR-MC=-2.0+1.2n-.08n^2$

[g] $ANR=\frac{NR}{n}=-2.0+.6n-.0267n^2$

In this illustration, average net revenue over time is maximized by selling at the end of 11.2 feeding periods (see column 7, Table 1). Note that this is earlier than the time at which *net revenue from a single lot* of cattle would be maximized (13.1 time periods; see column 3).

This relationship is clarified in Figure 1. Maximum net revenue from a single lot of cattle occurs at point A. But maximum *average net revenue over time* occurs at point B, where a line drawn from the origin is tangent to the net revenue curve. The slope of a line from the origin to any point on the curve measures average net revenue for that point in time. The steepest of all such lines is the tangent shown in the diagram; its slope thus represents the maximum average net revenue.

Note that this is also the point at which marginal net revenue—represented by the slope of the net revenue curve at each point—is equal to average net revenue—represented by the slope of the tangent line. (This is analogous to the familiar theorem in cost theory that minimum average cost occurs at the point where marginal cost and average cost are equal.) As feeding is continued beyond point B, the decreasing additions to net revenue (marginal net revenue) begin to pull the *average* net revenue

down from its maximum (compare columns 6 and 7 in Table 1).[2]

This illustration assumes that the net returns curve is the same for successive lots of cattle. What of the more realistic situation in which the feeder may anticipate, for example, that the market price for the next lot will be higher than for the present lot, with a consequent change in the net returns function? This will affect the most profitable length of time to carry the present lot.

The rule in this case follows very simply from the preceding analysis: the present lot should be carried only to the point where marginal net revenue from it equals maximum average net revenue anticipated from

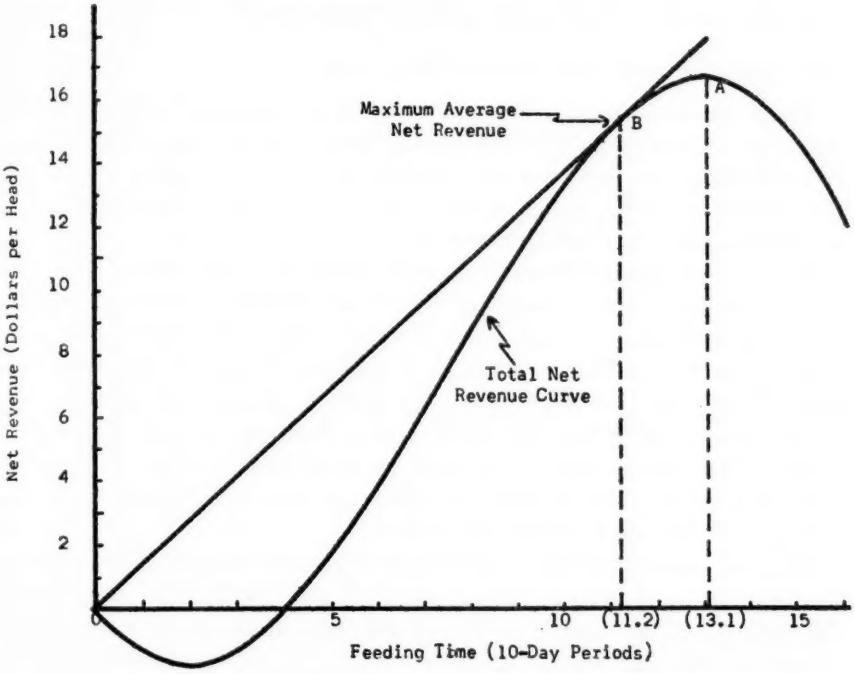

FIG. 1. TOTAL AND MAXIMUM AVERAGE NET REVENUE CURVES, FEEDER CATTLE ILLUSTRATION.

[2] This relationship can be shown mathematically as follows: Let $NR(n)$ be the net revenue as a function of length of feeding period. Then average net revenue over time, $ANR = NR/n$. This will be maximized at time n_m such that

$$\frac{dANR}{dn} = \frac{1}{n}\frac{dNR}{dn} - \frac{NR}{n^2} = 0$$

or

$$\frac{dNR}{dn} = \frac{NR}{n} = ANR$$

i.e., when marginal net revenue $\frac{dNR}{an}$ equals average net revenue.

the subsequent lot. To carry the present lot beyond this point would yield additions to net revenue less than the maximum average anticipated in the future. Hence it would pull the average down. This rule will also permit an optimum replacement time to be obtained when anticipated prices decrease, and when costs and/or physical relationships are expected to change for the next lot.

A Long Production Period with Revenue Being Realized by the Sale of the Asset

The problem of determining the optimum replacement pattern is complicated by introducing a long production period. The complications arise as a result of uncertainty and time preference.

Discounting returns and compounding costs

There are two basically different types of discounting to consider. The first type is that of using lower yields, lower prices and/or higher costs in calculating the expected net revenue. This is discounting because of uncertainty of yields, prices or costs. It does not usually entail the use of a mathematical discounting formula.

The second type of discounting arises from time preference. The logic of time preference discounting is that a sum of money received or paid at the present time is worth more than the same sum of money at some time in the future. This is primarily a function of opportunity costs. The more distant the time that the money is to be received or paid the less is the present value that the individual or firm places upon this sum of money. This relationship can usually be expressed in terms of a mathematical formula. The appropriate discount rate is determined by the supply and demand for loanable funds.[3]

An understanding of the relationships between a stream of net revenue (or net costs) and net revenue received (or costs paid) in a lump sum at different points in time is necessary for the remainder of the analysis. These relationships are presented algebraically and graphically in Figure 2. The arrows indicate the direction of the movement between different points in time.

The forestry enterprise[4]

A forestry enterprise will be used to illustrate the problems encountered and the principles involved in determining the maximum net rev-

[3] A discussion of the appropriate discount rate is presented in a recent empirical study of time relationships by A. J. Coutu, et al. *An Economic Evaluation of Soil Conservation Practices,* N.C. Agr. Exp. Sta. Tech. Bul. 137, Jan. 1959, pp. 22-31.

[4] There have been a large number of articles written on the optimum replacement age for timber production. An excellent critique of the techniques that have been

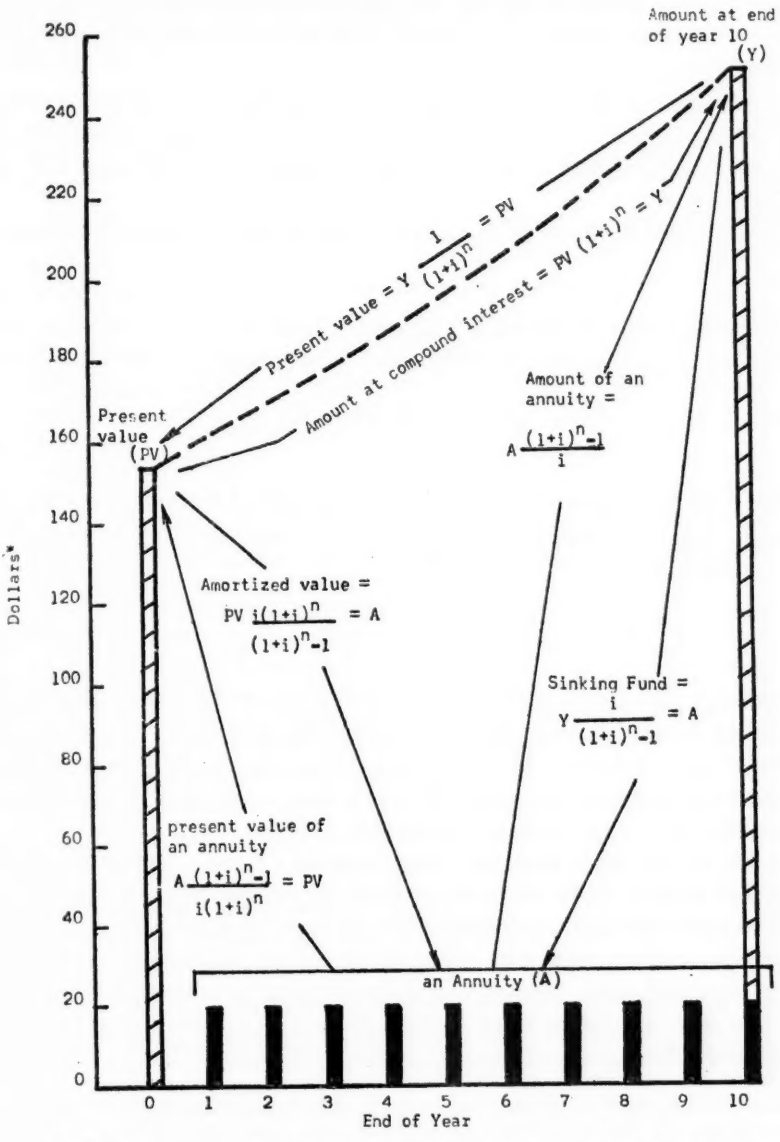

FIG. 2. RELATIONSHIPS BETWEEN A STREAM OF NET REVENUE OR COSTS AND NET REVENUE OR COSTS IN A LUMP SUM.

* Dollar values assume interest at rate $i = 5$ percent, compounded annually for $n = 10$ years.

enue over time for an enterprise with a long production period and with revenue being realized only by the sale of the asset. The technique will be set forth first and then an example will be used to illustrate the use of the technique.

In the forestry enterprise it is assumed that the operator has an initial cost of planting or establishing the trees and an annual cost of upkeep. It is also assumed that all the trees in any specified acre are cut and sold in the same year.

The establishing cost, a, is compounded at interest rate i.[5] Therefore,

$$a_n = a(1 + i)^n \tag{1}$$

The annual cost, b, excluding interest, is assumed to be the same each year. This is the equivalent of the amount of an annuity. Therefore,

$$b_n = b\frac{(1 + i)^n - 1}{i} . \tag{2}$$

Net revenue in year n is equal to the expected total revenue in that year, Y, less establishing and annual costs accumulated to year n. This can be expressed as

$$NR_n = Y_n - a(1 + i)^n - b\frac{(1 + i)^n - 1}{i} . \tag{3}$$

Equation (3) applies both to the expected net revenue from the present trees and from the trees that will immediately follow. The costs and revenues may, however, be different for the two stands of trees. This is because the operator may use different prices, costs and/or physical relationships on the following stand of trees.

At the end of each year the operator must decide whether to cut the trees and replace them or to leave them in another year. Therefore, he must compare the expected increase in net revenue from leaving the trees uncut for another year with the anticipated net revenue from the following stand of trees. However, it is not logically correct to use the principle set forth in the previous section and state that the present stand of trees should be cut when the marginal net revenue of the present stand

used in determining the optimum replacement date is presented by M. Mason Gaffney, *Concepts of Financial Maturity of Timber*, Dept. of Agr. Econ., A. E. Info. Ser. No. 62, Raleigh, September, 1957. The technique used in this paper, however, differs from the techniques discussed by Mr. Gaffney.

[5] The formulas for converting a stream of net revenue (costs) into an equivalent lump sum value, a lump sum value into an equivalent stream or equivalent sums from one point in time to another are presented in a large number of books of *Mathematical Tables*. See e.g., tables compiled by C. D. Hodgman, *Mathematical Tables from Handbook of Chemistry and Physics*, Ninth Ed., Chemical Rubber Publishing Co., Cleveland, 1948.

is equal to the average net revenue of the following stand. This is because the values are not being compared at equivalent points in time, i.e., within the same year. In order to make a valid comparison it is necessary to compare anticipated revenues at the same point in time. In this analysis the common point in time will be the present time. Therefore, in order to make the decision of whether or not to replace the trees the operator first must determine the present value of the anticipated net revenue from the following stand of trees.

In determining the optimum replacement pattern the concept of maximizing net revenue over time must be kept in mind. This concept implies that the stream or flow of net revenue is to be maximized over time. Thus the present value of the net revenue in year n can be converted into an equivalent stream of income for the following stand in order to compare it with the marginal net revenue from the present stand. This is accomplished by multiplying Equation (3) by the sinking fund formula,

$$\frac{r}{(1+r)^n - 1}$$

(see Figure 2).[6] Thus the amortized present value of anticipated net revenue, A_{NR_n}, can be expressed as

$$(4) \qquad A_{NR_n} = \left[\frac{r}{(1+r)^n - 1}\right]\left[Y_n - a(1+i)^n - b\,\frac{(1+i)^n - 1}{i}\right]$$

where r denotes the discount rate for time preference and i denotes the interest rate for the annual and establishing costs.

To be consistent the marginal net revenue from the present stand of trees may be considered as a stream for one year.[7]

When the marginal net revenue from the present stand of trees becomes smaller than the anticipated stream of net revenue from the stand of trees immediately following it is proftable to replace the present stand. It is now possible to restate the principle of optimum replacement for enterprises with long production periods and with returns being realized by the sale of the asset. *The optimum time to replace is when the marginal net revenue from the present enterprise is equal to the highest*

[6] Tables for the sinking fund formula are not available in many of the books of *Mathematical Tables*. If these tables are not available, the sinking fund can be obtained by subtracting the interest rate from the amortization formula. Thus

$$\frac{r(1+r)^n}{(1+r)^n - 1} - r = \frac{1}{(1+r)^n - 1}$$

[7] The present value of the amortized *marginal* net revenue for one year is the same as the marginal net revenue.

amortized present value of anticipated net revenues from the enterprise immediately following.[8]

A numerical example is presented in Table 2 in order to illustrate the techniques and principles presented above.[9] It is assumed that no salable lumber is available for the first 20 years. An establishing cost, $a = \$14.00$ and an annual cost, $b = \$1.30$ per acre are also assumed. The effective interest rate (for both i and r) is 3 percent, i.e., the operator can borrow or invest money elsewhere for 3 percent per annum.[10] The establishing

TABLE 2. PRODUCTION COSTS AND REVENUES PER ACRE FOR TIMBER PRODUCTION

Age of Tree (Years)	Total Revenue	Establishing Cost[a]	Annual Cost[b]	Total Cost	Net Revenue	Marginal Net Revenue[c]	Average Net Revenue
0	$ 0	$ 14.00	$ 0	$ 14.00	$−14.00	—	—
1	0	14.42	1.30	15.72	−15.72	—	—
10	0	18.81	14.90	33.71	−33.71	—	—
20	22.00	25.28	34.93	60.21	−38.21	$ 4.89	$−1.91
30	174.00	33.98	61.85	95.83	78.17	19.94	2.61
40	510.00	45.67	98.02	143.69	366.31	21.55	9.16
43	585.00	49.90	111.13	161.03	423.97	18.05	9.86
45	630.00	52.94	120.54	173.48	456.52	15.68	10.14
46	651.00	54.53	125.45	179.98	471.02	14.50	10.24
48	688.00	57.85	135.73	193.58	494.42	*11.11*	*10.30*
50	721.00	61.37	146.64	208.01	512.99	8.68	10.26
53	763.00	67.07	164.25	231.32	531.68	5.00	10.03
54	775.00	69.08	170.48	239.56	535.44	3.76	9.92
59	825.00	80.08	204.53	284.61	*540.99*	.45	9.16
60	834.00	82.48	211.97	294.45	539.55	−.84	8.99
70	918.00	110.85	229.77	410.62	507.38	−7.22	7.25
80	*993.00*	148.97	417.77	566.24	426.26	−11.77	5.33

[a] An establishing cost of $14.00 per acre is assumed with a compound interest rate of 3 percent per annum.

[b] An annual cost of $1.30 per acre is assumed with a compound interest rate of 3 percent per annum.

[c] These are interval estimates.

Source: The total revenue, establishing costs and annual costs by 10 year periods were taken from Kenneth P. Davis, *American Forest Management*, McGraw-Hill Book Co., Inc., New York, 1954, p. 240. The figures for the other years are interpolated.

[8] Actually, the principle of optimum replacement is the same for the short production period, e.g., the feeder cattle illustration. In the short production period the discount rate for time preference is zero.

Therefore, $\frac{1}{(1+r)^n} = 1$ and $\lim_{r \to 0} \frac{r(1+r)^n}{(1+r)^n - 1} = \frac{1}{n}$ in the short production period.

When the net revenue is multiplied by $\frac{1}{n}$ the average net revenue is obtained.

[9] The gross revenue, stablishing costs and annual costs used in this example were obtained from Kenneth P. Davis, *American Forest Management*, McGraw-Hill Book Co., Inc., New York, 1954, p. 240.

[10] Although a 3 percent interest rate is not very realistic at the present time, it probably was realistic at the time the costs and revenues were calculated.

cost for any year is \$14.00 plus interest compounded at 3 percent per annum.[11] The total annual cost for any year is the accumulated \$1.30 per year plus interest compounded at 3 percent per annum.[12]

It is further assumed that the expected costs, prices and physical relationships for the next stand of trees, s_2, are identical to those for the present stand, s_1.

In this example the maximum total revenue per acre occurs after the 80th year. The maximum net revenue per acre is obtained in the 59th year, and the marginal net revenue and the average net revenue are approximately equal in the 48th year. The present values of net revenue were calculated for selected years using a discount rate of 3 percent per annum (Table 3). The maximum present value occurs in year 46. The maximum amortized present value of \$4.96 occurs in year 43 (Table 3).

In applying the principle of optimum replacement it is evident that the present stand of timber should be cut at the end of the 53rd year. It is in this year that the marginal net revenue from the present stand, s_1, is approximately equal to the highest amortized value of the following

TABLE 3. MARGINAL NET REVENUE AND PRESENT VALUES AND AMORTIZED PRESENT VALUES OF NET REVENUE PER ACRE FOR TIMBER PRODUCTION

Age of Trees (Years)	Marginal Net Revenue[a]	Present Value of Net Revenue[b]	Amortized Present Value of Net Revenue[c]
20	\$ 4.89	\$−21.21	—
30	19.94	32.21	\$1.64
40	21.55	112.30	4.85
43	18.05	118.94	*4.96*
45	15.68	120.72	4.92
46	14.50	*120.93*	4.88
48	11.11	119.65	4.74
50	8.68	117.02	4.55
53	*5.00*	110.99	4.21
54	3.76	108.52	4.08
59	.45	94.47	3.43
60	− .84	91.58	3.31
70	− 7.22	64.08	2.20
80	−11.77	40.06	1.33

[a] The marginal net revenue was obtained from Table 2.

[b] This column was obtained by multiplying the net revenue in Table 2 by $\frac{1}{(1+.03)^n}$.

[c] The amortized present value is obtained by multiplying the present value of net revenue by $\frac{.03(1+.03)^n}{(1+.03)^n-1}$.

[11] This would be \$14.00 $(1 + i)^n$ or \$14.00 $(1.03)^n$.

[12] Because of the constant dollar input per year the formula for the amount of an annuity can be used. This is

$$\$1.30\left[\frac{(1+i)^n-1}{i}\right] \text{ or } \$1.30\left[\frac{1.03^n-1}{.03}\right]$$

stand, s_2.[13] If the trees were left uncut one more year the expected marginal net revenue would only be \$3.76 per acre from the present stand, s_1, but the expected flow of net revenue from the following stand, s_2, would be \$4.96 per acre per year.

This illustration does not imply that the following stand, s_2, would be replaced at the end of 43 years or that there is an infinite succession of stands planted every 43 years. In the first place it is extremely unlikely that prices, costs, physical relationships and discount and interest rates would be the same for stands $s_1, s_2, s_3 \ldots s_m$. However, if this were true, the stands would be replaced at the end of year 53 and *not* 43. Why? As was stated earlier the operator must make the decision of whether or not to replace the stand at the end of *every* year. The basis for the present time changes, e.g., ten years from now year t_{10} will be the year t_0. When stand s_2 is 43 years old the marginal net revenue will be \$18.05 but the maximum amortized present value from stand s_3 will only be \$4.96 assuming the same prices, etc. Thus stand s_2 would not be replaced until the end of year 53. The decision of when to replace is not determined by a succession of following stands but only by the stand immediately following.

A Long Production Period with Renvenues Being Realized Throughout the Life of the Asset

In the two previous sections the principles of replacement were discussed for enterprises in which the revenues were realized only at the time of the sale of the asset. The principle of optimum replacement for enterprises having a long production period and with revenues being realized throughout the life of the asset is the same as that for the timber enterprise where net revenue is received in a lump sum. However, there is a difference in the method of handling the planting and annual costs. In the following discussion a cling peach enterprise will be used as a point of reference for an enterprise having a stream or flow of revenue forthcoming over a number of years from the original investment.

Because of the flow of revenue from the cling peach trees the cost of establishing the trees can be repaid in most instances before the trees are replaced.[14] Therefore interest should be compounded only on the unpaid

[13] Another method of determining the optimum replacement age is to compare the marginal net revenue and the amortized present value of the net revenue for trees of the same age. When the marginal net revenue becomes lower than the amortized value it is time to replace the trees, e.g., in year 54 the former is \$3.76 and the latter is \$4.08. However, this is applicable only when the present stand and the following stand have identical net revenues.

[14] The establishing cost includes more than planting costs. The difference between gross revenue and annual costs over the period when costs are greater than revenues is also included in the establishing cost.

balance of the establishing cost. The operator may have set up the repayment schedule for establishing costs over a longer period of time than that required for accumulated net revenue from the enterprise to become greater than zero. This would result in a larger amount of interest being paid than if the establishing cost had been repaid as soon as possible from the net revenue from the cling peach enterprise.[15] This is irrelevant, however, when determining the revenues from the enterprise. The additional interest paid by the operator should not be charged to the enterprise but rather to consumption.

The net revenue in any year can be expressed as

$$NR_n = Y_n - a_{n-1}i - b_n - c_n \tag{5}$$

where Y_n is the gross revenue, $a_{n-1}i$ is the interest on the unpaid balance of the establishing cost at the *beginning* of the year (or the end of the previous year), b_n is the annual cost and c_n is the planting cost.

In order to obtain the amortized present value the present value of the net revenue must be accumulated. Thus the amortized present value in year n can be expressed as

$$A_{NR_n} = \left[\sum_{k=0}^{n} \frac{Y_k - a_{k-1}i - b_k - c_k}{(1+r)^k}\right]\left[\frac{r(1+r)^n}{(1+r)^n - 1}\right] \tag{6}$$

where $a_{-1} = 0$.[16]

The annual net revenue is also the marginal net revenue. The optimum replacement age, then, is when the annual net revenue from the present trees is equal to the anticipated amortized present value of the net revenue from the following trees.

Costs and revenues can be increased or decreased by a constant amount each year without changing the optimum replacement pattern. For example, assume that costs are decreased by \$50.00 per year. This would increase annual or marginal net revenue by \$50.00 per year for the present trees. The \$50.00 per year decrease in costs is the equivalent of an annuity of \$50.00 for the following trees. As the formula for the present

[15] In many instances this will not make any difference in the replacement date. For example if the unpaid balance of the establishing cost becomes zero in the 10th year but the operator has a repayment schedule of 15 years, the marginal net revenue and the amortized present value will be the same for both methods of computation after year 15.

[16] The amortization formula,

$$\frac{r(1+r)^n}{(1+r)^n - 1}$$

is also called the formula for an annuity whose present value is 1 or the formula for the periodic rent on an annuity.

value of an annuity is the reciprocal of the amortization formula (see Figure 2) they cancel out and the constant amount ($50.00) remains.[17] The marginal net revenue for the present stand and the amortized present value would both be changed by the same amount. The implication of this is twofold. The first implication is that fixed costs, in many instances, could be deleted from the cost calculations for this type of enterprise without materially changing the solution for the optimum replacement pattern.[18] The second implication is that operators with different fixed costs would have the same optimum replacement pattern providing the other inputs and outputs were similar.

Summary

The basic principle to follow with respect to the immediate replacement of enterprises that can be held variable lengths of time can be stated as follows. *The optimum time to replace is when the marginal net revenue from the present enterprise is equal to the highest amortized present value of anticipated net revenue from the following enterprise.* For enterprises that will be replaced several times a year the discount rate for time preference is zero. Therefore, the highest average net revenue may be used rather than the amortized present value, as the former is a special case of the latter, i.e., they are equal when the discount rate is zero. A constant amount per time period can be added or subtracted to the net revenue without changing the optimum time to replace an enterprise. In order to obtain the appropriate net revenue it is necessary to charge interest on the unpaid balance of the establishing or planting costs. This is true for enterprises that furnish a flow of net revenue as well as for enterprises where the net revenue is obtained by the sale of the asset. The techniques set forth in this paper should be applicable to a large number of different types of enterprises under varying yield, price and cost conditions.

[17] If the constant amount is denoted by k the amortized present value is

$$k\left[\frac{(1+r)^n-1}{r(1+r)^n}\right]\left[\frac{r(1+r)^n}{(1+r)^n-1}\right]=k$$

where the first term in brackets is the present value of an annuity formula and the second term in brackets is the amortization formula.

[18] Deleting fixed costs would reduce the unpaid balance of the establishing costs and thus interest payments. This would have the effect of increasing the amortized value. However, in previous work the author demonstrated that deleting fixed costs has little effect upon the optimum replacement age of cling peaches. See J. Edwin Faris, *Economics of Replacing Cling Peach Trees,* Calif. Agr. Exp. Sta. Giannini Mimeo. Rept. No. 232, Berkeley, June 1960, pp. 92-99.

SOME CONSIDERATIONS IN ESTIMATING ASSEMBLY COST FUNCTIONS FOR AGRICULTURAL PROCESSING OPERATIONS[1]

BEN C. FRENCH[2]
University of California, Davis

SUPPLIES of raw products required to increase the output of agricultural processing plants normally must be secured over widening supply areas or by raising prices to nearby farmers to obtain additional production.[3] In either case, procurement costs increase with plant volume and must be considered along with internal plant costs, and sometimes distribution costs, in evaluating the efficiency of alternative plant size, product volume, location, and industry organization. Raw products are commonly assembled with a variety of transportation and handling methods, from scattered locations and from diverse owners. Each assembly job is unique to a particular situation, and each situation or location involves a different relation between plant volume and assembly cost. This greatly complicates the derivation of useful relationships that may form the basis for practical generalizations or comparisons.

Various aspects of these complexities have been recognized for many years and have been incorporated in a number of empirical studies. Examples of pioneering work in this area may be found in the early Connecticut efficiency studies under the leadership of R. G. Bressler.[4] More recently, papers by Olsen, Henry and Seagraves, and a report by the author have provided further development and analysis of relations among average length of haul, plant volume, production density and marginal and average assembly cost.[5]

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[1] Giannini Foundation Paper 196.

[2] I am indebted to R. G. Bressler, G. A. King, L. L. Sammet and J. F. Stollsteimer for helpful comments on the paper.

[3] While both methods of increasing supply may ultimately require consideration, the present discussion is confined to the broadening of supply areas. For an interesting study of increasing production density versus expanding the supply area see William R. Henry and James A. Seagraves, "Economic Aspects of Broiler Production Density," *J. Farm Econ.*, Feb. 1960.

[4] See especially, R. G. Bressler, Jr. and D. O. Hammerberg, *Efficiency of Milk Marketing in Connecticut, 3. Economics of the Assembly of Milk*, Storrs Agr. Expt. Sta. Bul. 239, 1942. Other studies in this group pertaining to assembly costs include: D. O. Hammerberg and W. G. Sullivan, *Efficiency of Milk Marketing in Connecticut, 2. The Transportation of Milk*, Storrs Agr. Expt. Sta. Bul. 238, 1942 and W. J. Hansen and R. G. Bressler, Jr., *Efficiency of the Transportation of Eggs to Connecticut Cooperative Associations*, Storrs Agr. Expt. Sta. Bul. 241, 1942.

[5] Fred L. Olson, "Location Theory as Applied to Milk Processing Plants," *J. Farm Econ.*, Dec. 1959, pp. 1546-55. William R. Henry and James A. Seagraves, *op. cit.* B. C. French and D. G. Gillette, *Cost of Assembling and Packing Apples as Related to Scale of Operation*, Mich. Agr. Expt. Sta. Tech. Bul. 272, 1959.

The purpose of this paper is to enlarge on the theoretical framework evolved in these studies. Consideration is given to the general relation between assembly cost and plant volume, to a special case involving a square grid system of roads as is typical of much of the central United States, to multiple products, and to the problem of selecting efficient assembly technique and estimating long-run assembly cost functions.

The Supply Plane

Visualize a processing plant located at the origin of a set of coordinates, as indicated in Figure 1. The area around the plant is the supply plane and each point in the plane may be identified by the value of its rectangular coordinates (x, y) or its polar coordinates (r, θ). Actual road distance to any point will bear some approximate relation to r.

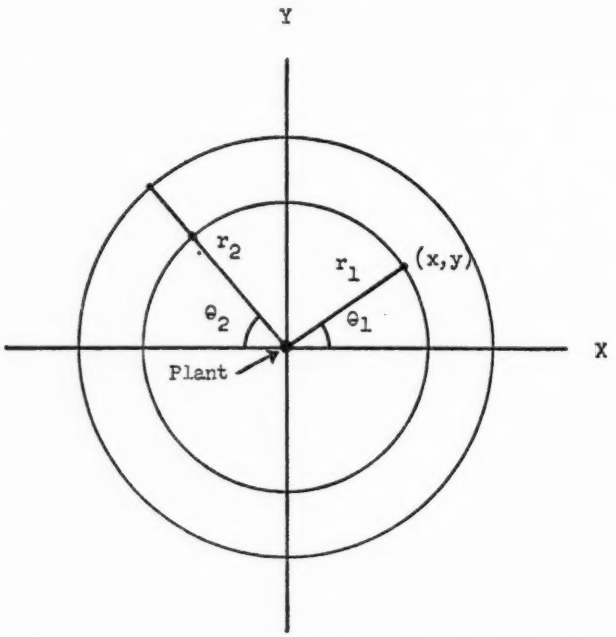

FIG. 1. CONCEPTUAL VIEW OF A CIRCULAR PLANT SUPPLY PLANE.

The plane itself might be visualized as being dotted with islands rising to different heights. The heights measure density of production and the volume of each island represents the supply of product available within the area covered by the island. Density may vary with distance, with time (seasonally, annually, secularly) and with product prices. Effective density (supply actually available to the processing plant) will also de-

pend on the activities of competing firms. Distance to the processing plant is measured from some central point or points within each island.

If the distribution and volume of each island of production is known it is a simple task to compute the total supply encompassed within any radius of the plant and the total travel distance involved.[6] Except in the unrealistic case where the islands of production run together to form a continuous production surface, the relation between supply and radius will be discontinuous. If the gaps between islands are not too large, however, a continuous approximation may provide a good indication of the underlying form of the relationship and also serve as a useful and convenient basis for further generalization.

Let $P = g(r, \theta)$ be a function giving the density of production at any point in the supply plane. Total supply (S) within any radius of the plant is found by summing the supplies for all points within the circular area defined. That is,

$$S = \int_0^{2\pi} \int_0^{r} g(r, \theta) r dr d\theta. \tag{1}$$

With uniform density $g(r, \theta) = P_0$ and

$$S = P_0 \pi r^2. \tag{2}$$

In this case total supply is simply the area of the supply plane multiplied by the density. Because of difficulties in finding the specific nature of the functions describing distributions of density, use of average density is commonly the only practical approach. Replacing P_0 by $\bar{P}$, the average density of all islands of production in the supply plane, gives a continuous approximation to the actual relation between supply and radius.

Relation of Assembly Cost to Plant Volume

The total cost of transporting the required supplies of a single product from any supply point to a processing or packing plant depends on the equipment used, the labor used with each piece of transport equipment, the work methods employed by the labor, the distance from the supply point (or route distance) to the plant, the speed of travel, the prices of inputs, the total volume of product handled per trip and per season, wait-

[6] If density varies throughout the area and if a series of stops is required to complete a load a plant may find it most economical to expand transport distance more in the dense areas than in the sparse areas of the supply plane. This then involves iso-cost zones which ordinarily would not be perfect circles. However, circular zones are appropriate for assembly operations involving a single stop to pick up a load (or a series of stops within small, roughly uniform areas such as orchards). In some cases involving several stops per load, the plant may have only limited practical control over the direction of route expansion and the use of circular areas may simplify the approach.

ing time at the plant or in the field, and minor environmental factors that may vary from time to time.[7]

Since changes in speed and volume per trip involve intensification on fixed factors there is no reason to expect the relationship among these variables to be linear. With most pieces of equipment, however, a linear function may be an acceptable simplification. The load capacity is often rather strictly limited by the construction of the equipment, and this limit may become effective before costs are increasing at an increasing rate. Moreover, volume per trip typically remains constant at or near some capacity level. Vehicle speeds are commonly restricted by road conditions and legal requirements, and the increasing-cost aspects associated with speed may reasonably and conveniently be averaged.

With these simplifications and with given hauling methods and input prices the *variable cost per unit of commodity* can be represented by (1) a constant part, b_0, associated with loading, unloading, and average waiting time and (2) a constant cost per unit of volume per unit of distance traveled, b_1, which includes costs of labor, gasoline, maintenance, etc.[8] For a single supply source the *total* variable cost of hauling any given volume, S, is

$$C = S(b_0 + b_1 D) = S(b_0 + b_1 wr) \tag{3}$$

where D is road distance, and w is a factor for approximately converting air distance to road distance. If the entire supply available at the supply source is hauled to the plant, total supply is, of course, identical with density of that point.

With several discrete supply sources the total variable cost per season is a sum of the cost from each distance, weighted by the volume trans-

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[7] There is no essential difference between transportation from a single point and a series of points such as an egg pick-up route, providing the same stops are made each trip. Most of the discussion that follows will be in terms of a single pick-up of a load or a series of stops within a small area such as an orchard, but extension to routes is not difficult, given the route organization. The interesting problem of how to arrange pick-up points into efficient routes is beyond the scope of this paper .

[8] For examples of such assembly cost functions see: George G. Judge and Ralph L. Baker, "Time and Cost Functions for Egg Routes," *Poultry Science*, July 1952, pp. 738-744. L. L. Sammet, *Efficiency in Fruit Marketing—Orchard to Plant Transportation*, Calif. Agr. Expt. Sta. Giannini Found. Agr. Econ. Mimeo. Rept. 131, 1952. E. L. Baum and D. E. Pauls, *A Comparative Analysis of Costs of Farm Collection of Milk by Can and Tank in Western Washington, 1952*, Wash. Agr. Expt. Sta. Tech. Bul. No. 10, 1953; Earl W. Carlsen, Lloyd Hunter, Raoul S. Duerden and G. F. Sainsbury, *Methods and Costs of Loading Apples in the Pacific Northwest*, U. S. Dept. Agr., Mktg. Res. Rept. No. 55, 1954; Paul L. Kelley, *Cost Functions of Bulk Milk Assembly in the Witchita Market*, Kan. Agr. Expt. Sta. Tech. Bul. 96, 1958; Robert H. Reed, *Economic Efficiency in Assembly and Processing Lima Beans for Freezing*, Calif. Agr. Expt. Sta. Giannini Found. Agr. Econ. Mimeo. Rept. No. 219, 1959; B. C. French and D. G. Gillette, *op. cit.*

ported from that distance. That is,

$$C = \sum_{i=1}^{n} (b_0 S_i + b_1 S_i D_i) = b_0 S + b_1 \sum_{i=1}^{n} P_i w r_i. \tag{4}$$

where S, D, P, w and r are defined as above and i refers to a particular source within the supply plane. The relation between assembly cost and plant volume is determined by cumulating supply and cost for the most distant source or sources in relation to increasing radius of the circular supply area.

If supply sources are continuously distributed, or can be so regarded for purposes of approximation, the summation of costs at the margin is replaced by the integral of such costs. With constant density the total variable cost of assembly is

$$\begin{aligned} C &= b_0 S + \int_0^{2\pi} \int_0^{r} b_1 P_0 w r^2 dr d\theta \\ &= b_0 S + \frac{2}{3} b_1 P_0 \pi w r^3. \end{aligned} \tag{5}$$

Since, from equation (2),

$$r = \frac{S^{1/2}}{\pi^{1/2} P_0^{1/2}}$$

assembly cost may be expressed directly as a function of plant volume. Substituting in (5) gives

$$C = S\left(b_0 + \frac{2}{3} b_1 w \frac{S^{1/2}}{P_0^{1/2} \pi^{1/2}}\right). \tag{6}$$

The terms within the parentheses give the variable cost per unit of product, which increases with volume, but at a decreasing rate.

Total variable cost can also be expressed as

$$C = S(b_0 + b_1 \overline{D}) \tag{7}$$

where $\overline{D}$ is the average length of haul. It follows from equation (6) that

$$\overline{D} = \frac{2}{3} w \frac{S^{1/2}}{P_0^{1/2} \pi^{1/2}} = \frac{2}{3} wr. \tag{8}$$

Again, P_0 may be replaced by $\overline{P}$, the average density, to obtain a continuous approximation to the actual relation between assembly cost and plant volume.

In much of the central part of the United States country roads follow along section lines, presenting a square grid system of roads. In this case,

the least costly area to haul from is not a circle but a square tilted 45° to the road net, as illustrated in Figure 2.

With this system the road distance to any supply point is simply $x + y$, where x and y are the rectangular coordinates of the point. If density

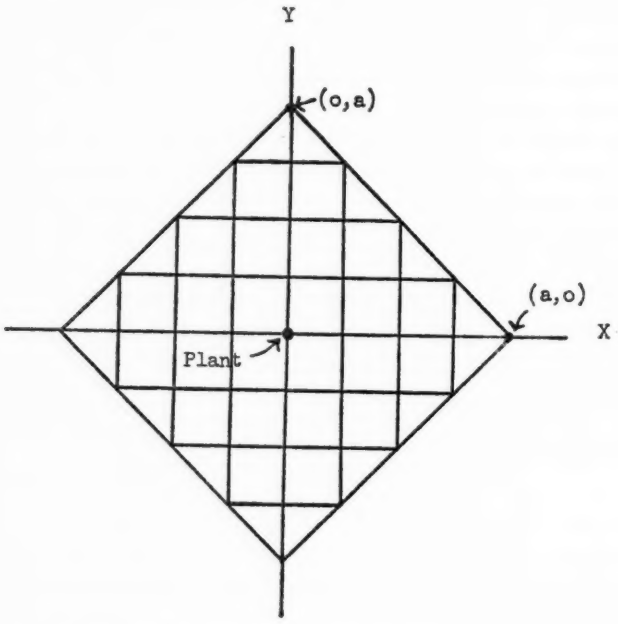

FIG. 2. BEST SUPPLY AREA FOR A SQUARE GRID SYSTEM OF ROADS.

is uniform throughout the supply plane the average travel distance for a square area with a diagonal distance of $2a$ is

$$\overline{D} = \frac{4}{\text{area}} \int_0^a \int_0^{a-x} (x + y)\,dy\,dx \tag{9}$$

$$= \frac{4}{2a^2}\left(\frac{a^3}{3}\right) = \frac{2}{3}a.$$

Total supply in relation to a is

$$S = 2P_0a^2 \tag{10}$$

and

$$\overline{D} = \frac{2}{3}\,\frac{S^{1/2}}{2^{1/2}P_0^{1/2}} = .4714\,\frac{S^{1/2}}{P_0^{1/2}}\,. \tag{11}$$

Equation (11) may be substituted in equation (7) to obtain an approximation to the relation between assembly cost and plant volume without reference to the relation between air distance and road distance.

If a circular supply area is used with the square road grid the average travel distance with uniform density is

$$\overline{D} = \frac{4}{\pi r^2}\int_0^r \int_0^{\sqrt{r^2-x^2}} (x+y)dydx \tag{12}$$

$$= \frac{8r}{3\pi} = \frac{8S^{1/2}}{3\pi^{3/2}P_0^{1/2}} = .4789\frac{S^{1/2}}{P_0^{1/2}}.$$

Comparing equations (11) and (12) indicates that the average length of haul necessary to obtain a given supply is slightly higher for the circular supply area, but the difference is quite small.

Over the long run, an allowance must be added for the fixed cost per season associated with ownership or rental of the transport equipment. This cost may be defined as FN, where F is the fixed cost associated with a single equipment unit (or group of combined equipment units) and N is the total number of such transport equipment units employed.

The number of transport equipment units required is determined by total assembly time requirements relative to the available working hours. That is, N is the smallest whole number such that

$$N \geqq \frac{T}{H} = \frac{S(g_0 + g_1\overline{D})}{H} \tag{13}$$

where H is the working hours effectively available, T is the total assembly time required, and $g_0 + g_1\overline{D}$ gives the assembly time per unit of product. The term g_0 includes some allowance for average time loss due to the impossibility of perfectly coordinating plant and assembly operations and H pertains to hours available for delivery plus additional hours that might be used for travel or loading, even though the plant was not receiving. Considerable variation in these magnitudes might be expected depending on location and the specific nature of the processing operation. Instances of delays due to "plant waiting for truck" or "truck waiting for plant" commonly are reduced through temporary storage of the incoming product and having receiving hours extend beyond plant hours. In many plants such storage costs are small relative to waiting costs. However, all of this leads into a queing problem which is beyond the scope of this paper.

The discrete variations in equipment inputs lead to discontinuous total and average total unit cost functions and complicate the calculation of meaningful marginal cost functions.[9] Empirical studies have usually ex-

[9] Marginal assembly cost functions do not appear to be essential, as such, for analyzing problems of plant size and location. Olson, *op. cit.*, computed such functions for use in deriving total variable costs of assembly but did not use them for other analytical purposes. Olson also assumed that costs associated with truck loading

pressed equipment costs as constant per unit of product or constant per unit of product per mile; in other words, equipment inputs have been treated as continuously divisible, rather than discrete.[10]

This certainly simplifies the problem and is probably a reasonable approximation in many instances. But note that some transport costs do remain essentially constant over extended ranges of volume and distance. Expressed on a per unit basis, these "fixed" costs decrease up to a point where each piece of equipment is utilized to its effective capacity, but increase overall as supply is increased since the volume of product that can be handled by each piece of equipment decreases as total travel distance increases.

Frequently assembly equipment is put to multiple use. It may be used for other products delivered to the same plant, to other plants, or for different kinds of operations altogether. If the different uses are at different times, the variable costs associated with each use or commodity may be determined independently. For a given assembly method the variable costs functions might appear as in equation (6), though with different density conditions in each use and possibly with different values for b_0 and b_1. The number of equipment units, and therefore the total fixed cost, will be determined by the commodity or use with the larger volume-distance requirements. Any allocation of fixed costs is purely arbitrary, although as a practical matter, some such allocation may be necessary in specific cases.

Selection of Efficient Technique and Level of Intensity

Typically, the type of equipment unit and hauling method is not given but is selected from the least costly of several alternatives. The alternatives may be defined in terms of assembly *technique* (a particular type of equipment combined with efficiently organized labor) and the *level of labor intensity* (the quantity of labor used in relation to the quantity of equipment). Different techniques and levels of labor intensity are associated with different values of the coefficients for cost (b_0, b_1) and time (g_0, g_1).

Suppose there is a given volume of product, S_o, to be transported from a single source to a processing plant within some time period, H. With S fixed at S_o, total assembly cost can be expressed as a linear function of distance—see equation (3). Assembly cost per unit of product is also a linear function of distance. Discontinuities will occur at distances where additional equipment units must be employed. The expected

do not vary with plant volume. Such costs may remain constant on a per unit of product basis but seem likely to vary directly with plant volume. Marginal cost of this component would be constant, but not zero as was apparently assumed.

[10] For example, see Judge and Baker, Henry and Seagraves, and Olson, *op. cit.*

breaking points may be found by manipulating equation (13) to obtain the expression,

$$D = \frac{1}{g_1}\left(\frac{NH}{S_0} - g_0\right).$$

Figure 3 illustrates the nature of the cost functions for alternative techniques and labor intensity and the selection of least cost methods for supply sources at various distances from the processing plant. For distances up to D_1 technique I gives the least cost. From D_1 to D_2 technique II is least costly, and beyond D_2, technique III. Additional curves, not shown, would be required to represent variations in labor intensity for each technique. Typically there may be some methods that do not give least cost for any distance.

If the volume to be transported, S_0, changes, the level of the cost curves and the locations of the discontinuities change. Altering the length of the assembly period, H, also shifts the discontinuities. Allowing S and

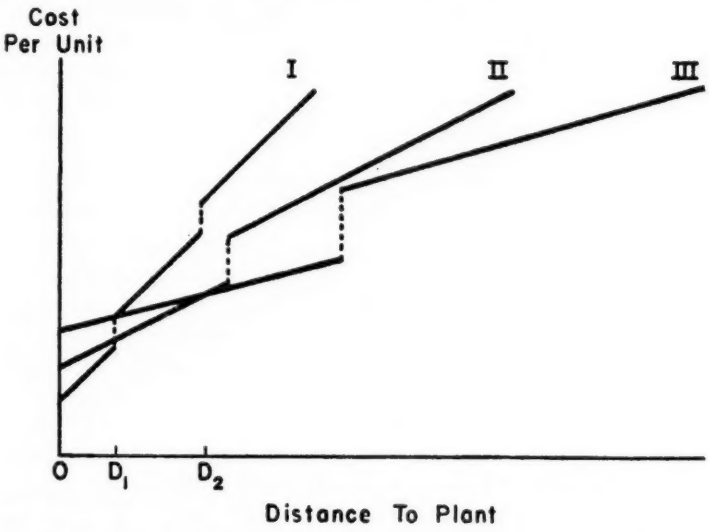

FIG. 3. RELATION OF COST TO DISTANCE FROM SUPPLY SOURCE TO PLANT FOR THREE HYPOTHETICAL ASSEMBLY TECHNIQUES AND GIVEN VOLUME OF PRODUCT.

H to take on all possible values defines the volume-distance-hours areas for which particular techniques and labor intensities give least cost and, correspondingly, defines the long-run transportation cost surface for efficient operation under these conditions.

The selection process becomes more complicated when a firm transports a single commodity to a processing plant from *several* fixed sources,

not necessarily simultaneously, but within some period, H. Selecting a *particular* technique and intensity is not the only possibility; a combination of techniques and/or intensities might be selected. For example, a firm with supply sources located both near and far from the processing plant might use, say, a tractor-trailer for the source near the plant and a large truck for the more distant supplies. If the truck had excess capacity at the distant range it might be used partially at both distances.

One approach to finding the least cost combination of techniques and labor intensity is to define additional assembly techniques, each of which is a particular combination of the basic techniques available. For example, various combinations might consist of a large truck and a small truck, two small trucks and a large truck, a tractor-trailer and a small truck, two small trucks only, and so on. Other combinations might involve variations in labor intensity.

By classifying assembly sources into a finite number of points in the supply plane the matter can be stated as a standard linear programming problem. Let i refer to a particular source ($i = 1, \ldots n$) and j refer to a particular technique and level of labor intensity ($j = 1, \ldots k$). The assembly cost function is

$$C = \sum_{i=1}^{n} \sum_{j=1}^{k} S_{ij}(b_{0j} + b_{1j}D_i) + \sum_{j=1}^{k} F_j N_j. \tag{14}$$

Equation (14) states that for a given set of sources and distances the total assembly cost is the sum of the volume (S_{ij}) transported by each single technique and intensity from each distance times the variable cost per unit for each single technique and intensity and distance, plus the total fixed cost for all items of equipment. For any combination of techniques and labor intensity and given S_i, D_i, there are many values of S_{ij} that will satisfy (14). The problem is to find the values of S_{ij} that will make cost as small as possible subject to the restrictions

$$\sum_{j=1}^{k} S_{ij} = S_i, \tag{15}$$

$$\sum_{i=1}^{n} \frac{S_{ij}}{M_{ij}} \leqq 1, \quad \text{where} \quad M_{ij} = \frac{HN_j}{g_{0j} + g_{1j}D_i} \quad \text{and,} \tag{16}$$

$$\text{all } S_{ij} \geqq 0. \tag{17}$$

The S_i's are the given quantities to be transported from each source, the M_{ij}'s are the season capacities of single techniques and intensities if used entirely for a particular source, and N_j is the number of multiples of equipment of technique j. Equation (16) gives the capacity restrictions for each single technique and intensity in transporting from various sources or combinations of sources.

Solutions to these equations, giving least cost combinations of techniques, may be obtained for all possible sets of supply-distance requirements.[11] The long-run relation between assembly cost and plant volume may be derived by cumulating total supply and total (least) cost in relation to increasing air distance from the plant. The specific nature of the resulting assembly cost function will be influenced by the institutional arrangements as to who provides the hauling service. If the assembly service is provided by the plant only one set of conditions or restrictions is involved. Where producers transport their own products and receive delivered prices, the selection of methods and corresponding costs depend on the separate conditions facing each producer and many restrictions and computations are involved.[12]

The sheer magnitude of the computations in these procedures plus the extensive and detailed information required leads us to seek approximate methods that give reasonably good estimates of assembly cost-supply relations. One approach is to compute the cost function for each technique for an average or typical volume of product transported from each supply source or concentration point or by each producer. The efficient range for each technique and the corresponding cost can then be determined as indicated in Figure 3 (assuming that a particular equipment unit serves only one source). A single smooth curve may be fitted to the points or segments of the cost curves that indicate least transport cost for supply sources of any distance to the plant. The assembly cost-supply function can then be represented by

$$C = \int_0^{2\pi} \int_0^{r} h(r) P_0 w r dr d\theta = P_0 w L(r) = P_0 w G(S) \tag{18}$$

where $h(r)$ approximates the relation between assembly cost per unit of product and distance, employing the optimum technique at each distance, for given time restrictions and given volume requirements for each supply source.[13]

Where assembly equipment is put to multiple use a reasonable approximation may be obtained by modifying the procedures suggested by equation (18). This will not be elaborated on other than to note that with dif-

[11] Feasible solutions will be possible, of course, only for combinations of techniques and intensities that have the capacities to meet the volume requirements. Some modifications would be required to consider the effects of operating a particular equipment unit at several levels of labor intensity.

[12] Assembly costs incurred by producers influence processing plant scale and location decisions through the effect on prices that must be paid to obtain desired supplies.

[13] For an empirical example, see B. C. French and D. G. Gillette, *op. cit.* This procedure has the advantage of permitting fixed equipment cost per unit of product to increase with distance from the plant. The magnitude of possible error or bias should, of course, be investigated in each application.

ferent commodities handled at different times, (a) variable costs are independent, (b) equipment requirements, and therefore equipment "fixed" costs, typically are determined by a single commodity use that has the larger volume-distance requirements, and (c) the distance range for which a particular technique and level of labor intensity gives least cost is determined in relation to a linear combination of total commodity supplies and the volume of the particular commodity that determines the equipment requirements.

Combining Plant and Assembly Costs

The combining of plant and assembly cost is largely a matter of simple addition. Using these combined functions in determining effcient size, location, and number of processing operations, however, is a most complex and interrelated problem. As indicated at the outset, specific solutions must be keyed to local situations, often with almost limitless possible combinations of locations and routes, and variations in other factors.

The practical approach therefore is to develop plant cost functions, to develop assembly cost functions under simplified situations as suggested above, and to add these to obtain indications of approximate over-all relations between volume and cost with efficient operation. This may involve not one addition but a series, each reflecting alternative density situations and, perhaps both long- and short-run costs. These combined functions may then be used as guides to evaluate the cost advantages of different potential locations and scales of operation, to consider the impact of varying supply density and, ultimately, along with other factors, to develop models of efficient industry or area organization.

OUTPUT AND INCOME EFFECTS OF REDUCING THE FARM LABOR FORCE

D. GALE JOHNSON
University of Chicago

THE continuing expansion of total agricultural output coincident with a declining farm labor force has caused many persons, including a number of agricultural economists, to question the efficacy of further reductions in farm labor as a means of increasing the returns to farm labor. Given the gross empirical relation between labor input and output, the conclusion is sometimes expressed that no foreseeable reduction in farm labor input would result in a sufficient reduction of farm output to bring about an increase in the returns to farm labor during the next few years. In fact, it is occasionally argued that further reductions in the farm labor force will only complicate the problem of agricultural adjustment by creating conditions for an even more rapid expansion of output.

In this article I explore two aspects of the relation between labor input and labor earnings. The first aspect is an investigation of the relation between farm labor input and farm output, which consists of working out the implications of certain very simple models and the analysis of combined cross section and time series data on labor and output in the United States. The second aspect is concerned with the relation between predicted and actual changes in the return to farm labor. The predicted changes are based on a simple model which emphasizes changes in the marginal physical product of labor as well as product price changes.

I. Output Effects

The output effects of reducing the quantity of labor in agriculture can be indicated by a reasonably simple analysis. Because of the confusion that sometimes exists in indicating the probable effects, it seems worthwhile to work through the general analysis and then through some illustrative cases before presenting any empirical evidence.

The static case

In a static situation it is almost certain that a reduction in one input in a firm or industry will reduce total output, if the firm and industry are in equilibrium prior to the input reduction. Figure 1 represents a simple case. The curves x_0 and x_1 indicate levels of output ($x_0 > x_1$) and a and b are the two inputs; the quantities of a and b being used are a_0 and b_0, respectively. The amount of b is reduced from b_0 to b_1; if the quantity of a remained at a_0, total output would fall to x_1.

The quantity of x produced may be greater or less than x_1, but will almost certainly be less than x_0. The reduction in the use of b would reduce the marginal physical product of a. Partially or completely offsetting the fall in the marginal physical product of a would be the increase in the price of x. If the supply function of a to this firm remains unchanged, the use of a cannot be as large as a_1, the amount required to maintain output at x_0. If output is unchanged, the price of x is unchanged; thus the amount of a demanded must fall due to the decline in its marginal physical product. Only if the supply function for a shifted downward as a result of the rise in the price of b, could the output of x be greater than x_0.[1]

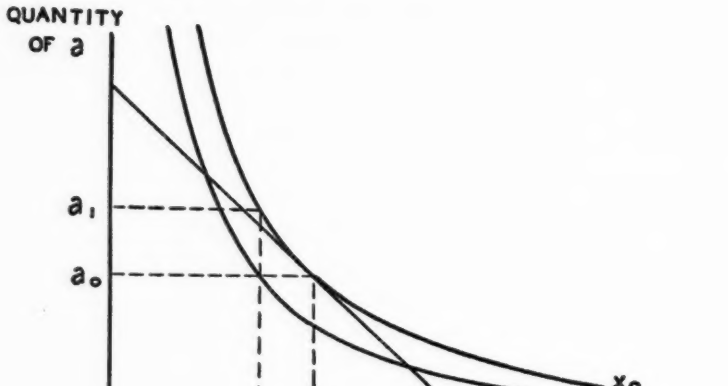

FIGURE 1

Now let us assume a production function and a demand function for an industry.

(1) $x = a^{1/2}b^{1/2}$ (production function for industry)
(2) $x = 50 - P$ (demand function for industry)

Until we indicate the supply functions for a and b we do not have a complete system. Let us assume for the moment that the price of a is 10 and the price of b is 10. In this case, x will be 30, and a and b will be 30 and the price of x will be 20.[2] The marginal physical product of both a and b

[1] It might be argued that if there is another input that is a perfect substitute for the reduced input, output need not fall. However, I am assuming that all perfect substitutes are in fact the same input.

[2] The solutions are obtained from the following four equations:

is ½; the price of x multiplied by the respective marginal physical products equals the price of a or b.

Now assume that the quantity of b is arbitrarily restricted at 25 and that the supply of a is perfectly elastic at a price of 10. Equilibrium will be reached at an output of x of 27.8 and a price of x of 22.2 and an employment of a of 30.9 units. The marginal physical product of a is 0.45, which when multiplied by the price of x gives a return to a of 10—the supply price for a.[3] If the output of x were to remain constant (at 30), the use of a would have to increase to 36. But this would imply a value of the marginal product of a of only 8.3—substantially less than the supply of price of a.

In the specific example chosen, the demand for a increased; this need not occur. Had the price elasticity of demand for x been unity the quantity of a used would have remained unchanged. If the demand elasticity had been greater than one, the quantity of a used after the reduction in the use of b would have been less than before. If in this example we substitute a different demand function:

$$x = 70 - 2P \tag{3}$$

and solve for the new equilibrium, we find that x equals 26.9, price of x equals 21.5 and the amount of a used is 29.0. The value of the marginal product of a is, of course, 10. But note that the quantity of a is less than 30; this is because the price elasticity of demand for x (about 1.3) is greater than the elasticity of substitution between a and b, which is unity for the production function chosen.[4]

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(1) $x = a^{1/2}b^{1/2}$

(2) $x = 50 - P$

(3) $\frac{1}{2}\frac{x}{a}P = 10$

(4) $\frac{1}{2}\frac{x}{b}P = 10$

($x/2a$ is the marginal physical product of a, which when multiplied by the price of the product must equal 10, the price of a.)

[3] The following three equations are given:

(1) $x = a^{1/2}\sqrt{25}$

(2) $x = 50 - P$

or

(2a) $P = 50 - x$

(3) $\frac{1}{2}\frac{x}{a}P = 10$

[4] The price elasticity of demand is estimated for quantities and prices in the range under consideration. In all references to price elasticities derived for linear demand functions, the statement refers to a specific or relevant range of quantities and prices.

The above results are summarized in the top part of Table 1. The bottom part of the table, in the section labelled disequilibrium, illustrates what could occur if the industry is not in equilibrium at the outset. The industry is assumed to be substantially out of equilibrium and employs 16 of a and 56.25 of b to produce 30 of x. The industry is out of equilibrium in the sense that the supply price of both inputs is assumed to be 10, but with either demand curve the value of marginal product of a is 18.8 and of b is 5.3.

The last two lines of Table 1 indicate the consequences of arbitrarily reducing b to 36 and reducing the value of the marginal product of a to 10 (its supply price) by increasing its quantity. With either the elastic or inelastic demand curve, output increases at the same time that there is a substantial increase in the value of the marginal product of b.

TABLE 1. NUMERICAL ILLUSTRATION OF CONSEQUENCES OF CHANGES IN INPUTS[a]

Situation	Output x	Inputs a	Inputs b	Marginal Physical Product of[b]— a	Marginal Physical Product of[b]— b	Price of x P	Value of Marginal Product of— a	Value of Marginal Product of— b
(1) Equilibrium	30	30	30	0.50	0.50	20	10	10
Input b restricted								
(2) Demand inelastic	27.8	30.9	25	0.45	0.56	22.2	10	12.4
(3) Demand elastic	26.9	29.0	25	0.47	0.54	21.5	10	11.6
(4) Disequilibrium	30	16	56.25	0.94	0.26	20	18.8	5.3
Input b restricted								
(5) Demand inelastic	32.1	28.7	36	0.55	0.44	17.9	10	8.0
(6) Demand elastic	33.2	30.5	36	0.53	0.46	18.4	10	8.4

[a] Based upon a model that assumes the production function $x=a^{1/2}b^{1/2}$, input price $P_a=10$, and alternative demand functions for the product: $x=50-P$ (inelastic in the equilibrium situation) and $x=70-2P$ (elastic in the equilibrium situation).

[b] The marginal physical products are given by $x/2a$ and $x/2b$, respectively. Multiplying these by P gives the value of the marginal product.

These examples indicate that, if the industry is out of equilibrium, a move toward equilibrium can result in an increase in output and a fall in product price. An increase in output is not inevitable if industry equilibrium is achieved as can be seen by comparing examples (4) and (2) or (3) in Table 1. Starting from the disequilibrium situation described in example (4) output would fall if the marginal opportunity cost or supply price of b is greater than 10 and if the value of the marginal product of a is reduced to its supply price. If the marginal opportunity cost of b is 10, achieving industry equilibrium starting from the situation of example (4) would result in no change in output; if the marginal opportunity cost of b is less than 10, output would increase.

The dynamic case

By the dynamic case is meant simply that the production and demand functions change over time. Because of increased knowledge or improve-

ments in the quality of inputs that are not measured in the input quantities, the output from the same quantities of inputs is greater at the end of a given period of time than at the beginning.

If we consider only the production function for the moment, it is certainly possible that a reduction in the quantity of one or both inputs is consistent with an increase in output over time, even if the industry is in equilibrium at the beginning and the end of the period.

Assume the following production function:

$$x = 1.02^t a^{\frac{1}{2}} b^{\frac{1}{2}} \tag{4}$$

According to this function, if t is measured in years, output will increase by 21.9 percent in 10 years if the quantities of a and b are held constant. If a is held constant, b would have to be reduced by about one-third for the output not to be greater in year 10 than in year 0.[5]

The above example indicates that if the quantity of b declines by anything less than a third, output will increase. Some may incorrectly conclude from such a phenomenon that reducing the quantity of an input has no effect on output, or even that reducing the amount of the input caused an increase in output. In the assumed situation, however, a reduction in one input causes a reduction in output compared to what otherwise would have been produced at the end of the period.

We may now introduce a demand function which also shifts over time:

$$x = 1.01^t (50 - P) \tag{5}$$

Assume that the price of a remains constant at 10 throughout the period and that the price of b, reflecting the general increase in factor returns, increases from 10 to 12.

The solution for year 10 is:

$x = 35.4$	$a = 31.8$
$P = 18.0$	$b = 26.5$

The quantity produced increased by 18 percent, while the amount of a increased by 6 percent and the quantity of b used declined by 11.7 percent. The total quantity of inputs, measured by beginning period prices, decreased by 2.8 percent; if measured by end period prices, by 3.6 percent

If the quantity of b had remained constant during the period, but the quantity of a were adjusted to equate the value of marginal product of a to a supply price of 10, output would have been about 4 percent greater and the value of marginal product b would have been 10.2. It is reasonable to say that a decline in the amount of b employed by somewhat less

[5] Assuming $a = b = x = 30$ at time t_0, then if $a = x = 30$ at year 10, b would equal 20.19.

than 12 percent would have resulted in a decrease in output of about 4 percent. Yet actual output increased whether the quantity of *b* declined or not. Consequently, when the production function shifts over time, economists should be careful to state that a reduction of one or more inputs would reduce output below the level that otherwise would have prevailed. This may or may not result in a decline in absolute output.

This example also indicates that even when the price elasticity of demand is less than unity and the demand curve shifts at only one-half the rate of the shift in the production function, an increase in output is consistent with an increase in the returns to one or both factors. When it was assumed that the return to *b* increased from 10 to 12, this occurred with an increase in output of 18 percent and a price decline of 10 percent.

Empirical results

The above analysis indicates that we cannot say with certainty that a reduction of farm labor would reduce total farm output compared to the level that would prevail in the absence of the reduction of labor. If there is a particular kind of disequilibrium in the use of resources, a move toward equilibrium may result in an increase in output. If some or all of the inputs other than labor have a value of marginal product in excess of their supply price, a reduction in the use of labor may be accompanied by an increase in the quantities of the other inputs sufficient to increase output. A somewhat different possibility is that the reduction of labor in agriculture may result in a transfer of productive activities from the control of less "efficient" to more "efficient" entrepreneurs or managers. Such a transfer could result in an increase in the marginal physical product of such inputs as land, machinery and livestock.[6]

Has the extent of disequilibrium in resource use been so great or the gains from farm consolidation so significant that output increases have resulted from reductions in the labor force? If such were the case, agricultural areas with the greatest reductions in labor force should have had greater increases in output over time than areas with smaller reduc-

[6] This is the position taken by Earl Heady ("Adjustment Problems in the Cornbelt and Midwest," in Joint Economic Committee, *Policy for Commercial Agriculture*, 85th Congress, 1st Session, Nov. 22, 1957, p. 187). He says specifically: "The net effect of further reduction in the total labor [force] and in farm numbers and consequent increase in farm size will be to augment agricultural output for several years before it alone causes output to diminish." His discussion, it should be noted, is intended to apply primarily to the midwest and he does not generalize it to the entire country, as I have done here. Thus the empirical results reported here do not represent a test of Heady's position. It is the writer, not Heady, who has generalized the proposition to a description of national consequences. I have assumed that "it (reduction of labor) alone causes output to diminish" refers not to an absolute reduction of output but to a lower level of output than would have been produced if labor had not left agriculture and farms had not been consolidated.

tions or with absolute increases in labor. This represents what might be called an extreme form of the disequilibrium or consolidation hypothesis. However, I believe that a less extreme and more reasonable test should be applied. We know that in the absence of any change in the quantity of labor employed agricultural output would increase over time because of technological change, improvements in the quality of inputs and, perhaps, because of declining relative prices of certain inputs, such as fertilizer. If the amount of labor used changed at varying rates in different agricultural areas, and if output changes were not affected by the disequilibrium in the use of resources or farm consolidation were not an important contributor to gains in efficiency in the use of resources, the (relative) change in output due to a change in labor would be approximately indicated by the static elasticity of output with respect to labor.

In a competitive situation we may assume that the static elasticity of output with respect to any input is equal to the share of total production expenditures paid for that input.[7] On this basis, labor has constituted approximately 40 percent of all inputs, except interfarm purchases, for the period 1927 to date.[8] To illustrate the last sentence of the previous paragraph, assume two areas. In one area there is no change in the labor input and, due to technological change, output increases by 10 percent. In the other area, the labor input declines by 10 percent. Its output should therefore increase by approximately 6 percent, assuming that the disequilibrium or consolidation effects are unimportant. For a decline of 10 percent in the labor input should be associated with a 4 percent decline in output measured from the level of output that would have obtained in the absence of a reduction in labor.[9]

The data used to test the relationship between changes in labor input and changes in total output are the regional farm output and man-hours of farm work estimated by the Farm Economics Research Division of the U. S. Department of Agriculture.[10]

[7] See Zvi Griliches, "The Demand for Inputs in Agriculture and a Derived Supply Elasticity," *J. Farm Econ.*, 41:319 (May 1959).

[8] This is a somewhat rough estimate based on the methods described in D. Gale Johnson, "Allocation of Agricultural Income," *J. Farm Econ.* 30:724-49 (Nov. 1948). The share of labor in gross output, as defined, was about 43 percent during 1925-29 and 36 percent during 1953-58.

[9] This statement rests on several assumptions, or perhaps more accurately, there are several sets of assumptions that would make the statement a valid one. One such set is the following: (1) The elasticities of substitution between labor and all other inputs are approximately the same in the various regions; (2) the elasticities of demand for the output of the various regions are also approximately the same; (3) the elasticities of substitution are approximately the same as the *regional* elasticities of product demand and (4) technological change is neutral and affects all regions equally.

[10] The data are to be found in *Changes in Farm Production and Efficiency*, USDA

These data are available for 1919 through 1957. In addition, independent estimates of the labor input have been made and used as a check. Four periods of three years have been chosen for the analysis. The first is 1927-29, the last three years before the depression of the thirties. The second is 1939-41, the last three years before World War II and long enough after the great droughts for most of their influence to have disappeared. There was a national average decline of about 12 percent in man-hours of farm work between the two periods. The third period is 1947-49, the immediate postwar period. Between the second and third periods, man-hours declined about 16 percent. The fourth period is 1955-57, the latest available period. Man-hours declined an additional 18 percent. Averages of three-year periods were chosen to elminate some of the random effects of weather variations.

It will be noted that the periods are roughly a decade apart. This is in part accident, but it is in part purposive. If the recombinations of resources due to the exodus of labor were to increase output significantly, the effect should be evident within a decade. Or, to view the matter from the standpoint of those who believe that the withdrawal of labor will have a favorable effect through creating a differential reduction of output, albeit around a rising trend, this effect should also be evident in a decade.

The procedure used was to compare (by correlation and regression) the 9 regions with reference to each region's relationship between changes in output and changes in labor input occurring between two particular periods. Changes in output were measured by dividing the output of the later period by the output of the earlier period. Changes in labor input were similarly calculated. In effect, percentage changes in output are related to percentage changes in labor input. A significant and positive correlation coefficient (and regression coefficient) would indicate that a withdrawal of labor reduced output compared with what that output would otherwise have been if labor had not been reduced. If the withdrawal of labor had no effect on output or actually resulted in an increase in output, as the extreme form of the "consolidation hypothesis" implies, the correlation coefficients would be either zero or negative.

Table 2 gives the correlation coefficients between changes in output and three measures of the labor input for the 9 regions. The first group of coefficients are based on the man-hour estimates of the Agricultural

Stat. Bul. No. 233 (Aug. 1958). Additional data are provided in three supplements. A later source of similar data may be found in the same bulletin, as revised Sept. 1959. The later source divides the nation into 10 farm production regions, but provides data by regions only for 1939 through 1958. The results presented in the text are based on the 1958 version of Stat. Bul. No. 233, while the results obtained using the data from the 1959 revision are given in footnotes.

Research Service. Of the comparisons involving successive decades, the correlation coefficients are significant at the 5 percent level or better except for 1939-41 to 1947-49.[11] The comparisons involving periods longer than a decade result in coefficients significant at the 1 percent level.

TABLE 2. CORRELATION COEFFICIENTS BETWEEN CHANGES IN OUTPUT AND IN LABOR INPUT FOR NINE REGIONS, 1927–29, 1939–41, 1947–49, AND 1955–57, U. S. AGRICULTURE

Labor Measure	1939–41	1947–49	1955–57
Man-hours			
1927–29	0.85*	0.87*	0.86*
1939–41		0.41	0.86*
1947–49			0.70**
Census of Population			
1927–29	0.77**	0.73**	0.82*
1939–41		0.30	0.61***
1947–49			0.48
USDA Employment Estimates			
1927–29	0.77**	0.71**	0.86*
1939–41		0.42	0.63**
1947–49			0.59***

N.B. All the correlation coefficients are positive.

Levels of significance: * indicates 1 percent level, ** indicates 5 percent level, and *** indicates 10 percent level.

Sources: Output, USDA Stat. Bul. No. 233 (Rev. Aug. 1958), p. 6. Man-hours, *ibid*, p. 23. Census of population estimates are unpublished estimates made by the author. The labor input represents number of persons employed in agriculture.

USDA estimates are from Stat. Bul. No. 236, Sept. 1958; *Agricultural Statistics*, 1953, p. 566; and unpublished data supplied by USDA. Data for 1947–49 adjusted for comparability for correlations involving 1947–49 and 1955–57.

These data indicate clearly that there is an association between the changes in the labor input and changes in output. As the signs of the correlation coefficients are all positive, the association indicated is the opposite of that implied by the extreme form of the "consolidation hypothesis"; thus on the basis of these data one would have to reject that hypothesis.

The analysis based on the man-hour requirements published by ARS cannot be considered conclusive. The methods of deriving the estimates of man-hours are such that the level of output influences the labor input estimates. Thus the relationship between labor input and output may be "built in" the data.

Unfortunately, we do not have any other consistent series of estimates of labor employment by regions for agriculture. The USDA estimates of farm employment by regions, which are available since 1910, have re-

[11] The low correlation coefficient for 1939-41 to 1947-49 is not surprising because of very small variance in the change in man-hours and in output. The coefficients of variation for the period were about 4 percent for both variables; in the other decade periods the coefficients of variation were 8 to 10 percent.

cently been revised for the years since 1950.[12] The revised series differs quite significantly for certain regions from the longer run series.

I have made estimates, based on the Census of Population, of farm employment by regions for 1930, 1940 and 1950. These estimates can be used, with relatively moderate adjustments based on the USDA estimates, for 1927-29, 1939-41 and 1947-49. However, no very satisfactory independent estimate is available for 1955-57 except the USDA estimates of farm employment.

With the estimates based on the Census of Population, four out of six of the correlations are significant at the 10 percent or higher levels. Five out of six of the correlation coefficients based on the USDA employment estimates are significant at the 10 percent or higher levels.[13]

While the regression coefficients are of some interest, interpretation is made easier if the coefficients are converted into elasticities. Table 3 presents the three sets of elasticities, which were obtained by multiplying the regression coefficient by the ratio between the mean employment percentage in the second of the periods compared and the corresponding mean output percentage. The elasticities should be thought of as gross elasticities of output with respect to labor since no effort has been made to hold other inputs or technology constant. The elasticities reflect all of the forces that affected output simultaneously with the change in the labor input.

All of the elasticities are positive, which indicates that output increased most in the areas where labor input increased most or decreased least. Thirteen of the eighteen elasticities are greater than .40, the approximate estimate of the static elasticity of output with respect to labor based on the share of the total value of agricultural output, minus interfarm transfers, that has been received by labor in recent years.[14]

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[12] *Farm Employment, Monthly by States, 1950-57; United States, By Years, 1901-57; By Months, 1940-57.* AMS, USDA Stat. Bul. No. 236, Sept. 1958. Earlier data available in *Agricultural Statistics,* 1953, p. 566 and by request from USDA. For the comparison of 1947-49 and 1955-57, the revised and old estimates were linked together on the basis of the estimates for 1950.

[13] On the basis of the Sept. 1959 revision of Stat. Bul. No. 233, the correlation coefficients between output and labor indexes are (for 10 regions):

	1947-49	1955-57	1956-58
1939-41	0.11	0.60**	0.71**
1947-49		0.26	0.61**

Coefficients marked ** are significant at the 5 percent level. All coefficients are positive.

[14] The gross elasticities derived from data of the Sept, 1959 revision of Stat. Bul. No. 223 are:

	1947-49	1955-57	1956-58
1939-41	0.12	0.47	0.55
1947-49		0.25	0.39

All elasticities are positive.

TABLE 3. GROSS ELASTICITIES OF OUTPUT WITH RESPECT TO LABOR INPUT, NINE REGIONS, 1927–29, 1939–41, 1947–49 AND 1955–57, U. S. AGRICULTURE

Labor Measure	1939–41	1947–49	1955–57
Man-hours			
1927–29	0.85	0.56	0.61
1939–41		0.26	0.65
1947–49			0.76
Census of Population			
1927–29	0.58	0.34	0.48
1939–41		0.15	0.41
1947–49			0.62
USDA Employment Estimates			
1927–29	0.56	0.35	0.52
1939–41		0.23	0.44
1947–49			0.55

N.B. All elasticities are positive.

The implication of the difference between the estimated gross elasticities and the elasticity expected from the importance of the labor input implies that there was some tendency for the quantities of other inputs to be influenced by the change in the labor input.[15] Thus while there has been a general tendency for non-labor inputs in the aggregate to increase during the period under consideration, the percentage increase may have been less in the regions with the greater reductions in the labor inputs. Some evidence is provided by the work of Stout and Ruttan.[16] While their use of five instead of nine regions covers up a large part of the variability in the change in labor input, they found that in the three major regions with the greatest decline in labor between 1925-27 and 1953-55, the indexes of net inputs declined by roughly 20 to 30 percent, while in the Mountain region there was no change and in the Pacific region there was an increase of about 10 percent. However, in the context of the present analysis it is probably more appropriate to consider the changes in all inputs (including current expenses) other than labor. When relatively crude estimates are made it is found that the largest increase in all other inputs was in the Pacific region (a little more than 50 percent) between 1925-27 and 1953-55, while the next largest increase (somewhat more than 40 percent) occurred in the

[15] The output series is net of all input transfers within agriculture, such as purchase of feed and livestock, but includes purchases from non-agriculture. Roughly speaking the output series is an estimate of changes in the value added by agriculture for various regions plus the value of purchases from the non-agricultural sector.

[16] Thomas T. Stout and Vernon W. Ruttan, "Regional Patterns of Technological Change in American Agriculture," Purdue Agr. Exp. Sta., Jour. Paper 1214, Dec. 13, 1957 (ditto).

Mountain region.[17] The Northeast had the smallest increase, somewhat under 15 percent, and the North Central had an increase of about a fifth. The South, somewhat surprisingly, had an increase in inputs other than labor almost as large as the Mountain region.

Farmers have reacted approximately as we would expect them to—when the price (or opportunity cost) of labor rose relative to other inputs, they tended to increase the relative amounts of the other inputs. But since there was not perfect substitution between all other inputs and labor, the increase in the quantity of other inputs was not sufficiently large to offset the output effect of the decline in the quantity of labor.

The relationship between the changes in labor and in the ratio of output per unit of total input has some bearing on the view that farm consolidation and the related savings in inputs may have a significant positive effect on output. Again drawing on the results of Stout and Ruttan, we find the following for 1927-29 to 1953-55.

	Labor Input	Gross output per unit of total input[a]	Net output per unit of total input[a]
		(1927–29 = 100)	
Northeast	62	141	147
North Central	60	140	153
South	60	138	155
Mountain	72	121	145
Pacific	101	154	177

[a] Based on Laspeyres indexes. See Stout and Ruttan, *op. cit.*, pp. 8, 20–22, and 23.

These data would imply that there was no important relationship between the reduction in the labor force and increased in output per unit of total input, as conventionally measured. Since the inputs are weighted geometrically, the effect upon output of changes in the proportions of inputs that occurs when the labor input declines has been recognized.

II. Income Effects

Our consideration of the income effect of the reduction of farm labor is a limited one. We are concerned with the effect of the actual changes

[17] The changes in labor and in all other inputs, 1925-27 to 1953-55 (1953-55 as percentage of 1925-27; average of Laspeyres and Paasche indexes for "other inputs") were:

	Labor	Other Inputs
Northeast	62	113
North Central	60	119
South	60	138
Mountain	72	143
Pacific	101	152

in the employment of labor upon changes in the income received by farm labor over time. The question is not raised at this point whether the change in labor employment was too large or too small in terms of achieving the same rate of growth of the return to farm and nonfarm labor or in terms of narrowing whatever gap may exist between the levels of labor income in the farm and nonfarm sectors of the economy. These latter questions are primarily related to the functioning of the labor market and are not directly pertinent to the analysis of the relationship between employment and labor income.

There are two questions that are pertinent: First, what have been the changes in the average return to labor over the period from 1910 to date?[18] Second, what change in return to agricultural labor would one have expected, given the levels of employment and farm prices that actually prevailed? Given the available data and the nature of our tools of analysis, both of these questions are extremely difficult to answer, and at best the most we can hope for are reasonable approximations. But the policy implications of the questions are so important that even somewhat imperfect information seems preferable to not making the effort to answer the questions at all.

Four different estimates of the return to farm labor have been made. The one that I believe to be most satisfactory is derived by estimating the total return to land and buildings, based on rents paid extended to all land, and a return to property other than real estate capital. The other three are based on estimated wage rates, the total wages bill divided by the number of hired workers, and a residual return for labor derived by applying the farm mortgage rate of interest to the estimated value of farm land and buildings and other farm capital. In the analysis that follows I have used the estimate based on rents paid and the average of the other three. This last is an admittedly crude procedure, but it has been done as a check on the first. The estimates are presented in Table 4, columns 6 and 7.

[18] In an article, "Allocation of Agricultural Income," *J. Farm Econ.*, 30:724-49 (Nov. 1948), I estimated the return to farm labor and other resources engaged in agricultural production. Since the publication of the article, most of the underlying data series have been revised. Fairly substantial changes have been made in the estimates of farm employment and rent paid, the estimate of the value of farm property has been changed to include all crops held on farms instead of crops held for sale, and there have been revisions in most of the income and expense series. Consequently, it has been necessary to construct new estimates of the factor distribution of farm income. To make matters worse, one of the fundamental series—rent paid by farmers—is apparently suspect with respect to its accuracy. The following is quoted from *The Farm Real Estate Market* May 1958, p. 24, published by the Agricultural Research Service: "Net rents received by owners of rented land provide a measure of return to land that has certain advantages over residual estimates of income to land. However, estimating procedures are more complex and no reliable estimates of net rents are available for recent years."

TABLE 4. ESTIMATED INDEX OF MARGINAL PRODUCT OF FARM LABOR AND RETURNS TO FARM LABOR, VARIOUS PERIODS, 1910–1959 (1925–29 = 100)

Period	Index of Deflated Farm G.N.P. (1)	Index of Farm Employment (2)	Index of Deflated Farm G.N.P. Per Worker (3)	Farm Output Price Deflator (4)	Index of Marginal Product of Labor (5)	Index of Estimated Returns per Worker	
						"A" (6)	"Average" (7)
					(current dollars)		
1910–14	90	105	86	66	57	54	53
1915–16	96	106	90	72	65	61	61
1917–20	94	104	90	131	118	119	119
1921–24	92	103	89	91	81	69	78
1925–29	100	100	100	100	100	100	100
1930	96	97	99	86	86	72	90
1931–34	101	99	102	54	55	47	51
1935–36	96	88	99	74	73	76	70
1937–41	112	88	127	72	92	92	97
1942	128	82	156	107	166	178	152
1943–47	114	80	142	149	212	246	289
1948–52	116	76	153	190	290	294	325
1953–57	127	64	198	162	320	284	324
1958–59	134	58	232	165	382	332	348

Sources:
(1) *Survey of Current Business*, Oct. 1958, pp. 12–13, and *ibid*, Feb. 1960, p. 23.
(2) *Farm Labor*, Jan. 1959, p. 8, and *ibid*, Jan. 1960.
(3) Column (1) divided by Column (2).
(4) Same as (1).
(5) Column (3) multiplied by Column (4) to derive an index of estimated marginal product of labor measured in current output prices.
(6) For method of estimation, see my article "Allocation of Agricultural Income," *J. Farm Econ.*, 30: 726 (Nov. 1948). Described as Method "A."
(7) An average of three estimates—Method B, and Method C described in article referred to in (6) and farm wage rates (*Farm Labor*, Jan. 1959, p. 15).

How would we expect the returns to farm labor to change over time? This obviously depends upon what model or theory one accepts. If one estimates the returns to farm labor by subtracting from net agricultural income the estimated total rent on land and the return to other property, one finds that the share of labor is reasonably constant for the period from 1910 to date. If the data are estimated for periods of four or five years, one finds that labor's share varies from 57 percent to 66 percent. There does not seem to have been any trend in the share over the period of more than 45 years.[19] This suggests the possibility that the underlying production function may be of the Cobb-Douglas type and that technological change has been neutral throughout the period.

If these assumptions about the production function and technological

[19] The share of labor return in net agricultural income was as follows for various periods (percent):

1910-14	59	1931-34	62	1953-57	57
1917-20	62	1937-41	61	1958-59	61
1921-24	58	1943-47	66		
1925-29	65	1948-52	63		

change are reasonably correct, the estimated change in labor returns could be found by estimating the average output per unit of labor employed. Under the assumptions of a Cobb-Douglas type of production function, the marginal product is proportional to the average net product with the degree of proportionality equalling labor's share of the net product, or about 60 percent.

It is not possible, within our framework, to estimate labor returns on the basis of gross output of agriculture. Over the period of time certain functions or activities have been shifted from farm labor and capital to nonfarm labor and capital. Unless we include in our estimates of return to farm labor the estimates of the return to labor engaged in producing power through tractors and petroleum, we would be violating the assumptions of our analysis.

Accordingly, the estimates of expected labor return are based on the gross national product produced by agriculture. The Department of Commerce estimates are used, except that rents paid to nonfarm landlords are added to the published estimate of gross national product in constant dollars.[20] The procedure followed was to divide the index of gross national product produced by agriculture by an index of farm employment and multiply this figure by the output price deflator.[21] Under the assumptions made, the resulting index should be an indication of the changes in the value of the marginal product of farm labor. This is not an estimate of the real marginal product, but of the change in the value of the marginal product expressed in the current prices in which output is measured.

The estimated index of the changes in the value of the marginal product of labor are presented in Table 4 as are the two estimates of the average return per farm worker described above. All data have been converted into index numbers, with 1925-29 as a base. The results are quite striking. The correspondence between the index of the estimated marginal product and the two estimates of average returns is very close. The squares of the simple correlation coefficients between the estimated index of marginal product and the two estimated indexes of average returns are 0.95 and 0.97.[22]

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[20] *Survey of Current Business*, Oct. 1958, pp. 11-14. This article gives data for 1910-57. Estimates of gross national product for agriculture for 1958-59 made by writer on the basis of estimates given *ibid.* Feb. 1960, p. 23.

[21] The implicit price deflator for farm output is used rather than prices received by farmers since the former includes the effect of changes in the rental value of farm dwellings and farm products consumed in the home.

[22] These correlation coefficients and all others referred to in the remainder of the article exclude 1958-59. The estimates for these two years are based on less complete information than is available for other years. The inclusion of the latter two years results in squared correlation coefficients of 0.94 and 0.93 for the two estimates referred to above.

It is true that a certain amount of spurious correlation is involved. The marginal product estimate includes the prices received for farm products and certainly the estimated returns are highly influenced by the absolute level of prices received. If both the returns series and the marginal product index are divided through by the output price deflator, the squared correlation coefficients are 0.84 and 0.91. Thus the estimated marginal product measured in terms of output is highly correlated with average earnings measured in terms of output.

An alternative hypothesis that is sometimes advanced, and which seems to be implicitly assumed in proposals to increase the level of price supports, is that the level of labor earnings in agriculture is determined by the level of farm prices. There is a very high correlation between an index of farm prices received and the estimate of labor earnings that I have designated as "A" in Table 4; the squared correlation coefficient is 0.87. But if both the earnings and the price series are deflated by the index of prices paid by farmers, the squared coefficient declines to 0.36.[23] When the earnings estimate "A" and the estimated marginal product of labor are both deflated by the index of prices paid, the square of the correlation coefficient was 0.87. Thus the model which includes changes in output and changes in employment explains a far larger share of the variance in real earnings per worker than does the model that includes only changes in deflated prices received.

Some of the implications of the simple model that has been used to estimate changes in the marginal return to labor may be noted. First, over the period under consideration, changes in the marginal physical product of labor have been almost as important as changes in product prices in determining the change in the value of the marginal product of labor, expressed in current prices.[24] Between 1910-14 and 1953-57, the index of prices received increased by 142 percent, while the change in the marginal physical product was 130 percent. Second, the changes in the marginal physical product of labor have been much more important than changes in the relative prices of output in determining the changes in the value of marginal product in real terms. Again referring to the beginning and ending periods, real farm product prices declined by about 8 percent, while the change in the real value of the marginal physical product was about 120 percent and the change in real earnings per worker ranged from 83 to 111 percent increase.

[23] The index of prices paid for living and production items was used as a deflator. Because of the inclusion of farm wage rates, the so-called parity index is inappropriate for the present purpose.

[24] The changes in the marginal physical product of labor are due to the increase in the ratio of all other inputs to labor as the labor inputs have declined, to technological change, and to improvements in the quality of inputs, including labor.

Third, it is clear that output can increase, real farm prices can decline and the value of the real marginal product of labor can simultaneously increase. If the gross national product of agriculture increased 10 percent, real product prices decreased by 5 percent, and the quantity of labor declined 5 percent (say over a period of four years), the real value of the marginal product of labor would increase by 10 percent. Even if farm product prices decreased by 10 percent, the real value of the marginal product of labor would increase by almost 5 percent.

It should be noted that there appears to have been some tendency for earnings to lag behind the estimated value of the marginal product of labor during the last few years (since 1953). There are several possible explanations for the apparent lag. The choice of 1925-29 as the base for the indexes in Table 4 may be responsible, in part. Had either 1910-14 or 1937-41, the other two reasonably stable periods during the entire period, been chosen as a base, the discrepancy during 1953-57 and 1958-59 would have been less, though some discrepancy would still have existed. It may be pointed out that the positive difference between earnings and the estimated value of the marginal product for 1942 through 1947 and possibly through 1952 are probably due to profits realized by farm firms which are attributed to labor by the imputation processes used. Another explanation for part of the difference may be found in the depreciation estimates used. There is good reason to believe that these estimates are on the high side, especially since about 1949 or 1950. Accepting the estimates as published has probably resulted in an underestimate of labor returns for the past several years, perhaps by as much as 5 percent.[25]

Another possibility is that the assumption that the coefficients of the production function have not changed is incorrect. It was noted that the share of labor in net agricultural income according to method "A" was rather stable over the whole period. However, the share of labor in the net agricultural product (the production coefficient in the Cobb-Douglas production function) was lower in 1953-57 than in any other period. Furthermore, the share of depreciation or capital consumption, as estimated, of the gross national product from agriculture has increased from

[25] For the period 1950-57 the USDA estimate of net investment in motor vehicles and farm machinery is $1,795 million, while the net investment in buildings is estimated at $5,610 million. The change in the inventory of farm machinery during the period seems quite out of line with the estimate of net investment. The number of tractors increased by 1,291,000 or 38 percent; trucks by 793,000 or by 36 percent; grain combines by 326,000 or 46 percent; corn pickers by 289,000 or 63 percent; pickup bailers by 394,000 or 200 percent; and field forage harvesters by 174,000 or about 200 percent. The gross capital expenditures on machinery during the period amouted to $21.8 billions. My attention was drawn to this point by the work done by Zvi Griliches on the analysis of farm investment.

7.6 percent in 1910-14, to 9.2 percent in 1925-29, to almost 18 percent in 1953-57. The share of depreciation was a little more than 12 percent in 1948-52. Thus the labor coefficient in the production function, if that function related to the gross national product from farming, might have declined as much as 10 to 15 percent since 1925-29. Some of this decline may be spurious because of the excessive depreciation allowances, but much of it may be real because of the changed techniques of production in agriculture over the past thirty years.

Even if the labor coefficient does change over time as production techniques change, the effect of reducing the labor employed in agriculture will still be that of increasing the return to labor. However, a decline in the labor coefficient means that the magnitude of the labor adjustment problem is increased, since the effect on output of any given percentage reduction of labor is reduced. The possibility does exist that had the labor coefficient not declined the level of output would be greater than it now is, though this is by no means certain.

III. Summary

It has been indicated that the output effect of reducing the farm labor input depends upon the circumstances prevailing prior to the reduction. In a static situation, if the factor markets are far enough out of equilibrium, a decline in labor input could be associated with an increase in output. It was noted that a reduction in labor input in agriculture is associated with a reduction in the number of producing units and that the resource recombinations resulting might actually increase output.

An empirical test was made to determine whether either or both the disequilibrium or consolidation effects had been important enough to offset the output effect of a reduction in labor. The results indicated that the gross elasticity of output with respect to labor was as large as or larger than the static elasticity of output for more than half of the estimates made. Supporting data indicated that regional changes in the amounts of inputs other than labor were positively associated with changes in the labor input.

A simple model was used to estimate the relationship between labor input and average earnings per farm worker. The model, which was based on an implied relationship between the average and the marginal physical product of labor, explained a very large fraction of the variance of labor earnings, whether measured in money or real terms. The model also shows that output need not be reduced absolutely as a result of a labor outflow from agriculture in order for an increase in real labor earnings to occur.

THE NEW AGRICULTURAL PROTECTIONISM AND ITS EFFECT ON TRADE POLICY*

LESLIE A. WHEELER
International Federation of Agricultural Producers

FOR about a century and a half—say from the publication of the Wealth of Nations in 1776 to the year 1930—agricultural protectionism was popularly accepted as meaning the protection of agricultural producers in a given country from foreign competition by means of the tariff. This was the main way, and in most countries (including the United States) the only way, in which national governments intervened to influence the prices of and the trade in individual agricultural products. It was taken for granted that producers of export crops and livestock products were not in a position to be "protected" by the government.

But times have changed—radically. During the last thirty years a new kind of agricultural protectionism, involving widespread governmental intervention, has arisen. This intervention includes the restriction of competitive imports—but now more largely through quotas or de facto prohibitions than through import duties. It also includes the promotion of exports through direct or indirect subsidies and through governmental or quasi-governmental export monopolies.

The purposes of this paper are: (1) to describe, as briefly as possible, the nature of this development and how it came about; (2) to appraise its effect on trade policy (especially that of the United States); and finally, (3) to express certain views as to what the future may hold in these respects and what policy changes might be desirable (especially in the United States).

The New Agricultural Protectionism—What It Is and How It Developed

Broadly speaking the new agricultural protectionism consists of all governmental intervention designed to bolster the monetary returns received by agricultural producers on individual commodities. Such intervention may be grouped under four headings: (1) import restrictions including tariffs; (2) deficiency payments; (3) price support loans and purchases; and (4) export monopolies—either governmental or quasi-governmental. ("Marketing agreements" in the United States may be placed in the latter category.) The old protectionism consisted, almost entirely, of measures taken under the first of these headings. The new

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consists of measures taken under all of them. In other words, the old protectionism dealt with restriction of imports; the new deals with exports as well as imports.

In the following paragraphs it is proposed to show how the new protectionism developed in various areas of the world.

Developments in the United States

With the benefit of hindsight, it is not difficult now to date the new protectionism from the adoption, in the United States, of the Agricultural Marketing Act of 1929 (The Federal Farm Board). This was the first time in the United States that the government had ever intervened to bolster prices of *individual* agricultural products—except by means of the tariff. The theory back of the Act was that, by establishing a Farm Board and providing it with $500 million to loan to national co-operatives (with a view to their achieving virtual marketing monopolies) it would be possible to halt the ominous fall in agricultural prices.

The theory did not work out in practice—at least so far as halting the fall in prices was concerned. Production continued to rise and prices continued to fall and, in the end, the Board had to take over large stocks of wheat and cotton. It was during the Farm Board's tenure that the first export subsidy program—in respect to Pacific Northwest wheat—was sponsored by the United States Government.

The main defect of the Agricultural Marketing Act of 1929, as the Farm Board itself acknowledged, lay in its lack of authority to control (i.e., reduce) production. The Agricultural Adjustment Act of 1933 was mainly designed to remedy this defect by paying producers, out of processing tax returns, to reduce acreage. The authority to make such payments was overthrown by a Supreme Court decision in January 1936 and, subsequently, the Soil Conservation and Domestic Allotment Act was passed providing authority for payments to farmers for diverting land from "soil depleting" to "soil conserving" crops.

But, from the point of view of effects on trade policy, certain supplemental features of agricultural legislation of the 1930's were more important than those relating to production control. Two of these were: Sections 22 and 32—amendments to the Agricultural Adjustment Act. Section 22 provided authority for the imposition of import quotas when imports were threatening to interfere with agricultural programs. Section 32 allocated up to 30 per cent of the customs revenues of the United States for the purpose, among other things, of subsidizing the exports of farm products (except cotton).

But by far the most significant development, in relation to trade policy, was the inauguration of a program of loans to producers on commodities

owned by them. It was under this authority that the Commodity Credit Corporation was established and a program of "price support" loans was developed which has continued up to the present time. Before World War II these loans were applicable, at relatively low levels, to only a few "basic" crops. During the war they were extended to numerous other crops and to dairy products at much higher levels in order to secure increased production. It was the continuation by Congress after the war (for a period much longer than the two years originally contemplated) of these higher loan rates (together with greatly improved production techniques) which has led to the huge government stocks of "surplus" commodities during recent years.

Two other United States agricultural programs have a strong bearing on trade policy—those relating to sugar and wool. In 1934 a Sugar Act was passed which completely changed the sugar policy of the United States. Prior to that time the United States had relied on the tariff to protect domestic sugar producers. Under the Act of 1934, a system of import quotas, production quotas, and benefit payments was inaugurated which has continued without fundamental change ever since. In general, it may be said that the sugar program has met with the favor of domestic sugar producers; it has been preferred by foreign suppliers to the old system of a protective tariff; and it has been operated in such a way as not to penalize unduly American consumers of sugar. Co-ordinated with the International Sugar Agreement, the United States sugar policy has effectively removed sugar as a source of major conflict and irritation in American commercial policy—up to the time of Castro.

The wool program was inaugurated after World War II. Briefly stated, it provides for production incentive payments (deficiency payments) to producers in lieu of an increase in the protective tariff. This policy, too, has been preferred by foreign suppliers to the old one of relying exclusively on protective import duties. And, in the event, it has not had the effect of reducing imports of wool nor of greatly stimulating domestic production.

One more piece of agricultural legislation affecting trade policy needs to be mentioned. This is the well-known "P.L. 480" (successor to Section 550 of the Mutual Security Act of 1951) adopted in 1954 which authorized: sales of surplus agricultural products to foreign governments in exchange for inconvertible foreign currencies; grants of such products for foreign relief; and the barter of such products for strategic raw materials. During the first five years of operation under P.L. 480, about one-quarter of total agricultural exports from the United States were subsidized through P.L. 480. Altogether, during that period—including sales for dollars of government owned stocks at cut rate prices—about

two-thirds of American agricultural exports were subsidized by the United States Government.

The Wheat Board and price supports in Canada

For many years attempts were made in Canada, under provincial and federal legislation, to organize co-operatives for the marketing of grain with a view to their obtaining control over a sufficient part of the supply to enable them to obtain adequate returns to the producers. These attempts were not successful in the face of the price deflation of the late twenties and early thirties and, in 1935, the Canadian Wheat Board was established by the Federal Government. The Board did not, at first, have a monopoly over all wheat trading in Western Canada. But, in 1943, the Dominion Government abolished the trading of wheat futures on the Winnipeg Grain Exchange and, since that year, the Board has been the sole agency through which wheat produced in Western Canada could be marketed. In addition, the Board handles the marketing of barley, oats, and flaxseed.

Wheat is the only agricultural product concerning which the Canadian Government has established a trading monopoly. But Canada has intervened in the marketing of other products through price support legislation. In 1944, in order to protect producers against a possible drastic decline in prices after the war, the Agricultural Prices Support Act was enacted by Parliament. In 1958, this Act was succeeded by the most far-reaching price support legislation in Canadian history. The new legislation, applying chiefly to animal products, gives the government considerable leeway as to the methods to be adopted to maintain returns to producers at what it considers to be reasonable levels. At the outset, reliance was placed on government purchases. But recently, because of very large production of eggs and hogs, the government has substituted a system of deficiency payments, on restricted quantities.

Agricultural marketing boards in the southern British Dominions

During the mid-1920's a new form of governmental intervention in agricultural trade emerged in the southern British Dominions: the Union of South Africa, Australia, and New Zealand. This consists in the organization of governmental or quasi-governmental marketing boards for individual commodities—usually those on a substantial export basis. While many such boards are now in existence, the six most important (from the standpoint of control over exports) are those dealing with deciduous fruit and citrus fruit in the Union of South Africa; dairy products and apples and pears in New Zealand; and dairy products and meat in Australia. (The Australian Wheat Board is not mentioned in

this context because, as in the case of Canada, it is an outright government marketing monopoly.) All of these six boards, or commissions (except the Australian Meat Board which has export licensing powers), have complete monopolies of exports of their commodities from their respective countries. All are made up of representatives of producers and of governments although, in general, governments retain final authority in important policy decisions. These agricultural marketing boards in the southern British Dominions provide the best examples to be found anywhere in the world of co-operation between governments and producers in the marketing of agricultural products.

Promoting agricultural self-sufficiency in Europe

The countries of Western Europe, including the United Kingdom, constitute the world's largest agricultural import area. In most of these countries the dominant feature of commercial (and agricultural) policy was, for many years, the restriction of competitive imports as a means of achieving agricultural self-sufficiency. Prior to about 1930 this policy was implemented, almost exclusively (except in the United Kingdom and the Netherlands), through the imposition of high protective tariffs. Since that year new devices, such as import quotas, requirements for the mixing of domestic with foreign products, government import monopolies and deficiency payments to producers, have overshadowed protective import duties as instruments for discouraging imports and of encouraging further expansion in domestic agricultural production.

Only three outstanding aspects of this complicated subject can be mentioned in this brief account: United Kingdom agricultural policy; the European Common Market; and the special case of wheat.

The United Kingdom has been, throughout modern times, by far the largest importer of agricultural products. Its trade policies are, therefore, of special importance from the point of view of the present discussion. From the time of the repeal of the Corn Laws (agricultural import duties) in the 1840's, up to the decade of the 1930's, the United Kingdom was, essentially, a free trade country. With a few exceptions, notably the case of sugar beets, agricultural producers in the United Kingdom were subjected to the full impact of "cheap" imports from overseas. But this policy changed in the early thirties with the imposition of import duties on a number of agricultural products and, more importantly, with the inauguration of deficiency payments to producers of wheat and other cereals as a means of bolstering their incomes and encouraging larger production. During World War II and the early post-war years far-reaching governmental controls over agriculture, involving much state trading, were in effect. But in recent years the "new agricultural pro-

tectionism" in the United Kingdom has consisted chiefly of providing deficiency payments to producers and of establishing compulsory marketing boards. The effect of this change in policy is shown by the fact that the United Kingdom now produces more than 50 per cent of its food requirements, compared with about 30 per cent before the war.

The establishment of the European Economic Community probably constitutes the most important single development affecting trade policy in the world since the end of World War II. The general effect of this development will be to establish, in the course of the next few years, uniform tariff rates on imports from other countries into the six national markets of the countries concerned. This will mean that the rates of duty in the countries now having low tariffs (which are usually the larger importers) will be raised, and that the rates in the countries now having high tariffs will be lowered. (The rates in particular cases may differ from the mathematical average by reason of negotiations through GATT.) But so far as agricultural products are concerned the rates of duty in the regular tariff schedules will not be a matter of importance in influencing imports into the Community. (Tobacco may provide one exception.) It is now clear that the common agricultural policy (now before national governments for approval) will be, basically, a price support policy so far as the main crops and dairy products are concerned. The implementation of such a policy will require extensive intervention in the import and export trade of these commodities. For other commodities, and especially for meat and poultry, it appears that the aim will be to restrict imports of competing commodities, through the imposition of special import fees or otherwise, and to encourage, through subsidy payments where necessary, the exports of Community products. In general, therefore, it may be assumed that the level of protection against imported agricultural products will be at least as high as the average protection, in the past, on the six national markets—and it may be considerably higher. On the other hand, there is good reason to suppose that purchasing power of consumers within the Community will be higher than would have occurred in its absence and that this will lead to higher per capita consumption of such agricultural products as meat, dairy products and fruits and vegetables. The net effect of these factors on agricultural imports into the Community will, of course, vary considerably as between different classes of products. It is probable, for example, that imports of feed grain may be larger in order to permit the planned expansion of the livestock and poultry industries. Imports of oilseeds, also, will probably increase. On the other hand, wheat imports may be smaller and confined largely to high protein hard wheat needed to supplement the home produced soft wheat. Community im-

ports of animal protein products will be negligible in relation to Community consumption and may well be smaller even than Community exports.

Wheat offers the prize example of what may happen when drives for "self-sufficiency" get out of control. Before World War II there was not a single country in Western Europe that pretended, or aspired, to be a regular exporter of wheat. (France did produce occasional export surpluses and exported some wheat under subsidy.) When the current International Wheat Agreement was signed in March, 1959, four European countries—France, Sweden, Italy, and Spain—registered as exporters. In all of these countries high price supports accompanied by improved production techniques have encouraged an expansion of wheat producing facilities to the point where, in years of average or better weather conditions, these countries have substantial export surpluses. But, since their internal prices are higher than those in the international market, no wheat exports from these countries are possible except with the benefit of export subsidies.

The effect of state trading on trade policy

In the Communist countries the nasty commercial policy problems involved in import quotas, export subsidies, deficiency payments, etc., do not arise. The governments of Communist countries buy what they want to buy (partly for political reasons) and sell what they have and want to sell (also partly for political reasons). No rules of GATT, or any other international body, relating to trade policy can have any practical effect on the trade deals of Communist countries. Such deals can be influenced, if at all, only by international commodity agreements to which Communist countries become adherents. (This now is the case in respect to the International Sugar Agreement of which the U.S.S.R., Poland, and Czechoslovakia are members.)

In numerous non-Communist countries government intervention in foreign trade is commonplace. (India provides an outstanding example.) These are, for the most part, newly established countries with underdeveloped economies which feel it is necessary, for their economic advancement, to rely heavily on the power of central government. They do not feel—and who can say they are wrong?—that they can rely exclusively on private trade and private capital to bring about a sufficiently rapid improvement in their economies and in the standards of living of their peoples.

Significance of the Foregoing to Trade Policy

To sum up, the world's commerce in the main agricultural staples moving in international trade is now dominated by governments—on both the

export and the import side. (This is not true of trade in horticultural products nor, to the same degree, of the trade in animal products.) The best indication of this is that virtually 100 per cent of the world's trade in wheat at the present time is handled through government monopolies or is made possible by governmental subventions of one kind or another. In the case of rice, the bulk of the trade, most of which is between Asiatic countries, is on a government to government basis.

What does this mean, so far as trade policy is concerned? It means, simply, that the old rules of the old protectionism do not, and cannot, apply. For example, when a country establishes an export monopoly for a particular product, it also automatically establishes an import monopoly for that commodity. When, as in the case of the United States, government intervention takes the form of export subsidies to the private trade it is necessary to restrict imports because domestic prices are being maintained at levels higher than those prevailing in the international market.

But the most significant effect of the new protectionism on trade policy concerns the export side. The widespread use of export subsidies and of governmental marketing monopolies (either for individual products or as a part of general state trading systems) introduces a new, and important, element into the world's trade scene to which the rules of the old protectionism do not apply.

These "facts of life" are explicitly recognized in certain exceptions to the "General Rules" of GATT. On the import side, the best indication of this is the "waiver" granted to the United States permitting the imposition of quotas on imports of agricultural products when such imports threaten the operation of a price support program. (This opens up the possibility of "approved" import quotas for countries other than the United States.) On the export side the outstanding indication is found in the GATT rule on export subsidies.

The GATT rule states that export subsidies are prohibited—except in the case of primary products. In respect of those products (chiefly agricultural) export subsidies are permitted providing they do not secure for the subsidizing country more than a "fair share" of the total international trade in the commodity subsidized. But how are the "fair shares" determined? They are determined, in actual practice, by the subsidizing governments themselves!

In the light of the foregoing, it should be apparent that the General Rules of GATT are unrealistic—so far as concerns much of the international trade in agricultural products. They do not conform to the facts of modern agricultural political economy. And when exceptions have been made to the rules to make them conform to the facts, the result has often

been to permit individual countries—e.g. the United States—to pursue, with very little hindrance, unilateral policies contrary to the "spirit" of the General Rules of GATT.

To put the matter another way, governments have become heavily involved, on the export side, in the international trade in some of the major agricultural products and they are not prepared to have rules apply to them which were intended to apply to trade, on both the export and import side, handled by private entrepreneurs.

A *summing up*

Trade policy in most countries of the Free World (at any rate those adhering to GATT) is based on the presumption that international trade is carried on through private entrepreneurs and that the rôle of government is merely one of interfering with that trade to a marginal extent, and to a greater or lesser degree, through the imposition of restrictions on imports and, in some cases, the exaction of export taxes.

This presumption is not correct as regards a large part of the world's trade in agricultural products. Governments have become heavily involved, either directly—e.g. wheat in Canada and Australia, rice in Burma, and sugar in Cuba—or, indirectly—as in the case of the United States in respect to a wide range of products in agricultural trade.

This governmental intervention in trade, in most countries of the Free World, is an integral, and essential, part of more or less settled agricultural policies. For this reason international trade in many agricultural products must be considered in a separate category from trade in non-agricultural products.

The final section of this paper will examine the extent to which these agricultural policies—which have such an important bearing on trade policies—may be expected to be continued in the future. And, in the light of this examination, certain suggestions will be made as to trade policies and attitudes toward such policies—especially in the United States.

The Outlook—And Some Observations

In this final section, dealing with possible future developments, I propose to adopt a less impersonal form of presentation. Assessment of the future depends essentially on personal experience—and personal predilections. My own experience has consisted of twenty-eight years employment in the Department of Commerce, Agriculture and State—all in positions concerned with international trade matters—and nine years as Consultant to the International Federation of Agricultural Producers. My predilections will be apparent from the context.

Future trade and agricultural policies outside of the United States

It is not difficult to forecast the future trade and agricultural policies of countries other than the United States. In those countries, in general, governments are going to continue to subsidize agriculture in ways which will require considerable intervention in the foreign trade in agricultural products. (I leave out of account here the case of the Communist countries.) In most of these countries, the citizens appear to take it for granted that it is a proper function of government to intervene, as necessary, in economic affairs. In most of them public sentiment seems to assume that, because of its very nature, agriculture in particular requires the intervention of government. Therefore, unlike the position in the United States, the general lines of agricultural policy in these "other" countries may be taken as "settled."

Future policies in the United States

The position in the United States is quite different. It may even be regarded as unique. The United States does not now have, and never has had, a settled agricultural policy. From the days of the Federal Farm Board down to the present time, agricultural price support programs have been considered to be "emergency" measures. It seems to have been assumed, in most quarters, that, sometime in the uncertain future (in spite of the existence of the "emergency" measures), supply would adjust itself, automatically, to demand for American agricultural products as a whole; and that the government could then concentrate on its historic rôle of showing farmers how to grow two blades of grass where one grew before; of assisting them to secure more reasonable credit; and, of course, of protecting them against undue competition of foreigners in the domestic market. But this adjustment has not taken place.

Consequently, for more than a quarter of a century, the United States has been pursuing economic policies based on two completely different philosophies. One is the philosophy implicit in the Reciprocal Trade Agreement Act (or at any rate its early editions) to the effect that the interests of both agriculture and industry would best be served by a general lowering of barriers to world trade—i.e., by reducing governmental intervention in economic affairs. The other is the philosophy implicit in the Agricultural Adjustment Act to the effect that agriculture suffered from basic production maladjustments and that the powers of government were required to "adjust" the situation—including the powers to restrict imports and subsidize exports.

In the early years of this policy conflict, it was taken for granted by the responsibile authorities that Reciprocal Trade Agreements represented the permanent approach and the Agricultural Adustment Act the emer-

gency approach to the solution of the problems of American agriculture. In other words, the theory was that, as reciprocal agreements opened up the channels of world trade and permitted a larger flow of American agricultural exports, the programs under the Agricultural Adjustment Act could be gradually abandoned.

The theory did not work out in practice. Foreign markets for American agricultural products were not substantially "opened up"—partly because of the "new protectionism" already described. And World War II intensified old maladjustments in American agriculture and introduced some new ones. Since World War II, the position may best be described as an incredible "hodgepodge"—the details of which I do not propose to pursue in this paper. The end result has been the accumulation in the hands of the United States Government, according to the latest official statistics, of an "investment" in agricultural commodities to a "value" of about nine billion dollars.

Now, in the face of this situation, and the fact that farmers and others dependent directly upon agriculture for a living are becoming a declining proportion of the voting citizenry of the United States, it may seem foolhardy to suggest that the government will continue to "support" agricultural prices—and thus continue to pose serious problems in the field of trade policy. But that is precisely what I do suggest. It is not, in my view, a question as to whether the government will continue to be involved in the business of agriculture. The question is whether this involvement will continue to be haphazard, inefficient and extremely costly to the American taxpayer.

Seven propositions

I conclude by propounding seven propositions relating to United States agricultural and trade policy which in my view would, if implemented, tend to make its agricultural policy more consistent with its stated commercial policy and also contribute to a more orderly development of international trade in agricultural products.

Proposition Number One: Agricultural policy should consist, mainly, of individual programs tailored to meet individual commodity situations and problems; and in the development of such programs attention should be paid to their probable international implications and repercussions. Some commodities are on a definite import basis; others are on a definite export basis. Demand for some is relatively elastic; demand for others is inelastic. Some are produced in restricted areas while others are produced in almost all parts of the country. Some agricultural commodity problems are of such a serious, chronic, and widespread nature that they can be resolved only through nation-wide programs operated through a

federal agency under the terms of special legislation; others, and these represent the vast majority, could be handled by the producers themselves if they were properly organized and were supported by appropriate federal and state legislation.

Proposition Number Two: Chronic problems apply mainly to the big export crops—grains, cotton, and oilseeds. Up to the present time, no long-term "settled" policies have been established for these commodities—and therefore they present serious problems from the point of view of trade policy. The existing "emergency" programs for wheat and cotton have had the effect of putting the Government of the United States in the position of final determiner of the amounts of these commodities exported and of their export sales prices. As a consequence, the United States Government has a dominant influence, also, in determining the "world" prices for these commodities. (It is most regrettable that the 19th century view of a "world price" still lingers in legislative halls and executive offices in the United States.)

Proposition Number Three: There should be government price support programs for each of the export crops whenever such programs are approved (but not each and every year) by two-thirds of the producers in carefully delineated "commercial" areas. Such programs should also be contingent upon a limitation of production or of the supply placed on the market by producers. (I should not want it to be taken from this that I am advocating a limitation of supply to a narrowly conceived concept of the "commercial" market; on the contrary, I would propose that, taking account of existing surpluses, adequate allowance should be made for supplies which could be made available to under-developed countries on a non-commercial basis.) The effect of a policy of continued price support loans—even at lower rates than those heretofore prevailing—without restriction of acreage or production can be seen in the monstrous United States corn crop of 1959. Over-production in relation to available market outlets is bound to result from such a policy. The main reason for this is that Congress, which establishes price support levels, will never approve levels so "disastrously" low as to discourage an expansion of production by American farmers well equipped in land, fertilizers, and machinery.

Proposition Number Four: Price support levels for the export crops should bear some relationship—and not too distant a one at that—to an internationally agreed "fair price range" for commodities moving, on a commercial basis, in international trade. (Such a price range now exists for wheat in the International Wheat Agreement.) The United States should not aspire to be a large exporter of wheat and cotton, for example, unless American producers of these crops are prepared to produce and sell these products at prices that are satisfactory to other leading export-

ers. But, at the present time, under the system of price support loans (which the United States does not appear likely to abandon in favor of government marketing monopolies such as exist in other exporting countries), the domestic market prices for export crops are largely determined by the loan rates. If the domestic price is higher than prices at which other exporting countries are prepared to export (which is usually the case) the United States Government must pay, directly or indirectly, an export subsidy in order to get a share of the business. Such subsidy payments are a burden on the United States taxpayer and an embarrassment in foreign relations. They could, and should, be reduced. (Internationally agreed "fair price" ranges can only be established through formal international commodity agreements which are discussed under Proposition Number Seven.)

Proposition Number Five: For commodities other than the main export crops, producers should take a more active rôle in solving their own problems. There are a considerable number of cases where producers—through their own organizations—are taking effective action to resolve their marketing problems. But these cases are confined largely to specialty crops grown in restricted areas—e.g. California fruits and nuts. Even in these cases of "self-help," however, producers find it necessary to borrow extensively from the powers of government—through marketing agreement or similar legislation. For this reason, while leaving in the hands of private, or quasi-governmental, organizations the detailed "business" operations relating to the marketing of particular commodities, it is important that the federal government retain the right to determine broad policies in the public interest. (Unfortunately, this is much more difficult to accomplish in a government of "divided powers" such as that of the United States where the "Secretary" is constantly harassed by "suggestions" from Congress than it is in those parliamentary systems where the word of the "Minister" is decisive.)

Proposition Number Six: There should be more multilateral, and less bilateral, activity in the supply of agricultural products in aid of economic development. At present, most of this activity is carried on by the United States unilaterally—especially through P.L. 480. Such unilateral, or bilateral, action has a number of disadvantages. It gives rise to protests from other agricultural exporting countries that the United States is invading their commercial markets. It discourages the participation of other developed countries in the supply of economic aid to under-developed areas. And last, but not least, it throws most of the burden of supplying aid, in the form of agricultural products, on the American taxpayer. A broad international, multilateral program participated in by all economically developed countries for assisting the development of the less-de-

veloped countries should be inaugurated, in which the supply of surplus agricultural products would represent only a part.

Proposition Number Seven: The United States should take a positive, rather than a dogmatically negative, view of the possibilities of international commodity agreements as means of reducing short-term fluctuations in prices in world commodity markets—and also of reducing international friction caused by unilateral export subsidy programs. The acceptance of this proposition would require a complete reversal of the position of the Executive Branch of the United States Government. This position—antagonistic to the principle and to the practice of commodity agreements—apparently stems largely from two presumptions: one, that commodity agreements are "cartels" and are bad *per se;* and, two, that commodity agreements encourage—or are responsible for—the entry of government into the sphere of private enterprise. Both of these presumptions are unwarranted. Commodity agreements are not cartels because: (1) they are participated in by governments, not by private interests; and (2) they are participated in by governments of both exporting and importing countries—i.e., by both producers and consumers. (Cartels are, by definition, combinations of producers.) And commodity agreements have not been, in the past or in the present, responsible for any more governmental intervention in the enterprise of agriculture than would have taken place in their absence. Indeed, it might be argued more cogently that the entry of governments into the business of agriculture, on nationalistic bases, is one of the factors contributing to conditions which make international co-operation through commodity agreements highly important in certain cases. It is important for one thing related directly to trade policy—in order to make more sense out of the GATT rule on export subsidies. It is important more generally as a practical means (if governments have the will to co-operate) of reducing, through intergovernmental action, instability of prices of primary agricultural products on the international market.

THE FARM PROBLEM: A CHALLENGE TO SOCIAL INVENTION

PETER DORNER
University of Wisconsin

FARMERS in the United States are confronted with two major problems. These can be classified as:

1. The price-income problem,
2. The organizational problem.

The latter can be sub-classified into:

a. The problem of capital accumulation and growth within the lifetime of the operating generation,

b. The problem of transfer between generations.

In the past several years, major emphasis in policy studies has been on the price-income problem. Recently, however, there has been increasing concern over the problems of capital accumulation and transfer. Adoption of vertical integration, central milking cooperatives or cow pools, and the corporate form of economic organization are illustrative of attempts to cope with the capital accumulation problem. In farm transfer, increasing emphasis is placed on land contracts, selling farms on a product payment basis, father-son agreements, the idea of a permanent mortgage, and again the idea of incorporation as means of facilitating transfer.

These organizational problems of farmers in the 1960's are quite similar to those confronting British factory owners a century ago. In both cases, the problems grew out of a rapid adoption of the "machine process" of production. Machines and related technologies create unique problems which the old economic organizational forms cannot meet successfully since they were developed to meet the problems under a different system of technology and production.

As is well known, the "machine process" became applicable in industry several centuries ago. Ability to organize and direct economic production gradually moved out from the home into the factory. Larger machines required more capital and larger factories. Individual ownership could not meet this challenge. This gave birth in mid-nineteenth century to the corporation with its subsequent concentration of production and economic power. The factory system evolved into the "corporate system."[1] It is only in recent times that the "machine process" on a large scale became applicable to agricultural production. Its major impact was not apparent until after 1940.[2]

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[1] A. A. Berle and G. C. Means, *The Modern Corporation and Private Property* (New York: The Macmillan Co., 1932).

[2] U. S. Dept. Agr., *Changes in Farm Production and Efficiency: A Summary Report*, Stat. Bul. No. 233, Rev. Sept. 1959.

The focus of the present paper is on the organizational problems in agriculture. The first section defines the nature of these problems. This is followed by a brief review of the British experience whereby the unlimited joint stock company was modified and transformed into the limited liability corporation. In the third section I have tried to show the implications and the lessons for American agriculture inherent in this historical experience. This is followed by a proposal for modifying present organizational forms and making them more serviceable in meeting the present needs of agriculture—namely, increasing capital and facility in transfer.

I. The Nature of the Problems

American agriculture is for the most part organized around farm families on family farms. Traditionally, these farms have been refinanced every generation. But capital intensive technology is becoming applicable to agriculture at an increasing rate. There is virtual assurance of a continuing out-pouring of new technologies. Even if research at the experiment stations would cease, the "technological revolution" in agriculture would continue. Research is today widespread in the corporations supplying agriculture. Methods necessary to regulate this research would hardly be acceptable.

Excluding major catastrophes such as war or widespread drought, there are no real prospects for increasing profit margins in farming in the foreseeable future. Our agricultural productivity and the potentials yet to be realized are too great to hope for much improvement. Even with government price support programs, there is evidence that under the declining price conditions of recent years farms have needed at least $25,000 or more in annual sales to maintain their net income position. Smaller farms, even though in the high production category, have shown substantial declines.[3] The investment required for a farm of profitable size may soon grow as large as one-fourth to one-half million dollars. Such units, I would hypothesize, will be too small to go directly to financial markets with corporate stocks and too large for the traditional refinancing each generation by existing credit institutions.

Declining profit margins require an expanding volume of sales per farm and likewise expanding investments. In the period 1945-1959, the farmer who wished to maintain a rate of growth in net income equivalent to that of nonfarmers had to double his physical volume of sales. This reflects increasing farm costs, declining prices, and increased reliance on

[3] Nathan M. Koffsky and Ernest W. Grove, "The Current Income Position of Commercial Farms," in *Policy for Commercial Agriculture*, Joint Comm. Print, 85th Cong., 1st Sess., Nov. 22, 1957, pp. 79-90.

nonfarm inputs, as well as the rate of growth in per capita income of nonfarmers. It appears that the next fifteen years will require another doubling of sales volume if farm income is to keep pace. Part of this increased volume per farm will come from more intensive production from present acres and animals; but a large part will come from expansion in farm size. The USDA has recently estimated that by 1975 there will be two million commercial farms compared to about three million at present.[4]

Many of the present farm families had the advantage of the prosperous forties. High incomes in those years permitted a rapid rate of growth from internal earnings. But this is not in prospect for the foreseeable future.

There is another difficulty on the horizon. This is the prospect of farms larger than the labor of one family can operate. Efficient production with modern technology requires expansion of business beyond the laboring ability of one family. This is especially true in dairying and will become more pronounced as the feed storage and handling operations become more and more mechanized. This may at first appear contradictory, but the limiting factor in dairying is the number of cows one person can milk, even with the most modern methods. It now appears that the cost of "barnyard" mechanization will require a herd size which is larger than the average family can well handle.

This is also related to several significant sociological factors. It is widely recognized that urban areas set the standard of living to which the population aspires generally. This standard of living includes more leisure time, vacations, etc. Family operation of a business as confining as agriculture, and especially as dairying, becomes an obstacle to the realization of some of these aspirations.

Equally important is the fact that most farm children now go through high school. As a consequence, children are not so readily available for work on the farm. Thus, the labor force of the farm family is smaller than in former years.

Also, children are engaged in a variety of organized activity both in and out of school which makes them less available for farm work. To deny them these experiences is hardly a solution. They increasingly need both the education and the participation in organized activity even if they remain in farming. It is especially crucial if they leave the farm for jobs in the city, since this places them in direct competition with urban youth who have had the advantage of such educational experience. The

[4] Kenneth Bachman, "Prospective Changes in the Structure of Farming," Presented at the 36th Annual Outlook Conference, Nov. 1958. The estimate is based on a projection of present trends.

importance of this is seen when we note that in the thirteen North Central states from 1945 to 1954, farming opportunities were available for only a third of the boys born on farms. The remaining two-thirds entered nonfarm occupations.[5] Very likely the next decade will see an even greater percentage leaving the farm.

The increased complexity of machine operations and the quality standards of farm products will require high quality labor. This will introduce an additional cost factor. Wage scales for high quality labor will place additional cost burdens on farm income. All these factors will tend to accentuate the problems of capital acquisition and transfer.

If this interpretation is correct, what are the available alternatives for dealing with these problems? Technology is today available for organizing farms on a much larger scale than the present average size of even the commercial farms. But to suggest a scale of organization sufficiently large to deal with the dual problems of capital acquisition and transfer in a manner similar to the way industrial corporations deal with them is not very useful. We may eventually have this type of organization in agriculture. But such a new organization within agriculture *must grow out of that which at present exists.* Any proposal for organizational change must explicitly recognize the existence of some three million commercial family farms.

We might suggest placing a limit on farm size and thus alleviate the problems of capital acquisition and transfer. Agricultural policies in France have in fact protected the small scale family operation.[6] But this too is impractical. We will not ignore the present trends in technological developments with their necessary implications for increased farm size. There are no indications of a willingness to interrupt progress in this regard.

Implicit in our agricultural policies is a course somewhere in between the above two suggestions. This is made most explicit in the Farm Security and Farmers Home Administration legislation. Congress apparently wants to retain a family-organized agriculture which is prosperous enough to expand farm size and thus able to adopt modern technology and increase production efficiency. Thus, the most reasonable alternative is to provide some new arrangements which will permit the existing family farms to cope with these capital problems. The economic organization of agriculture may well evolve into something different from that which we have at present. The exact nature of the outcome can never be foreseen. But such organizational modification or social invention is the

[5] Don Kanel, *Opportunities For Beginning Farmers, Why Are They Limited?* North Cent. Reg. Pub. No. 102, *Nebr. Agr. Expt. Sta.*, Bul. No. 452, April 1960.

[6] A. Whitney Griswold, *Farming and Democracy* (New Haven: Yale Univ. Press, 1952).

procedure we have always followed in the United States. In fact, it is the only procedure acceptable under a system of private property, free enterprise and democratic government.

The institutional arrangements of the future must permit capital accumulation and farm size expansion during the lifetime of the operating generation. This is largely a process of transactions with firms and families on the outside. In addition, there must be ease of transfer between generations, a process that is becoming more and more an intra-family affair.[7]

This is the nature of the organizational problems facing farmers. They will get more acute with each passing year. Economists have not given these problems the attention that they have given to the price-income problem. Yet, alleviation of these organizational problems is closely related to the measures that can acceptably be employed in solving the price-income problem.

The price-income problem will more readily lend itself to solution as the problems of capital accumulation and transfer are comprehended and modified. Basically, the struggle today is not so much between farmers and nonfarmers as between "big" farmers and "little" farmers. The issue comes to focus when dealing with supply control proposals designed to "solve" the price-income problem. The widespread appeal of acreage allotments without cross-compliance as well as of the soil bank lies in the fact that this cleavage and conflict within the agricultural community is hidden. Recent proposals for marketing quotas bring this conflict into clear view.

A reasonable solution to the price-income problem could be devised quite simply through the marketing quota approach if:

1. All farms produced only one commodity,
2. All farms of a given type were of the same size,
3. All farms were sufficiently large to operate efficiently with the most up-to-date technical methods of production.

Yet even as recently as 1954, 68 per cent of all commercial farms in the United States were under 100 acres in size. For dairy farms the corresponding percentage was 79. Even cash-grain farms had 32 per cent in this size category.[8] Although farms have been combined at an increasing rate in the past five years, the size distribution of commercial farms within any type-of-farming class covers a very wide range. What in fact exists is multi-product firms of widely varying size and operating with technologies ranging from horsepower with its appropriate implements to

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[7] Roger W. Strohbehn and John F. Timmons, "How Do Owners Get Their Farms?" *Iowa Farm Science*, Dec. 1959, Vol. 14, pp. 9-11.

[8] 1954 Census of Agriculture, Vol. II, Gen. Rept., pp. 1284-85.

something approaching mechanized factory production. The conflicts arise over the available means of growth and expansion to accommodate the new technologies in an efficient manner.

The idea of negotiable marketing certificates[9] is an attempt at devising a system of supply control to alleviate the price-income problem while at the same time minimizing the conflict inherent in the organizational problems. However, even here the large farm will have an advantage over the one attempting to grow large. Obviously not all the present farms can grow into large ones. Some will be combined with others and cease to be operated as independent units. The problem, however, is one of equalizing the opportunities for expansion between farmers who have already achieved "bigness" and those who are in the race trying to achieve it.[10] Stated another way, it is the problem of more nearly equalizing the market accessibility to funds for expansion. Likewise, it is a problem of constructing a market to facilitate the transfer of these increasing aggregations of capital. If a system can be devised to achieve this, then the question of supply control methods to ease the price-income problem will become less complicated.

Devising such a system is an exercise in social invention. This is where we can learn something from the British experience of a century ago. How was the factory system transformed to meet the challenge? The next section reviews this experience.

II. Social Invention: A Lesson From History

In Britain, as well as on the Continent, the 1850's were restless years. France had experienced her revolution of 1848. Marx had issued the Communist Manifesto. The struggle between capital and labor in the first half of the century had been acute. People were perplexed by the hardships amidst the promised and potential plenty.

John Stuart Mill, having been encouraged by some apparent success in Paris and London in 1848 and following years, predicted cooperation's ultimate triumph. "The form of association," he wrote in 1852, "which, if mankind continue to improve, must be expected in the end to predominate, is not that which can exist between a capitalist as chief and work

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[9] Willard W. Cochrane, *Farm Prices: Myth and Reality* (Minnesota: Univ. of Minn. Press, 1958), Chap. 8.

[10] The question may be raised: Why interfere with arrangements that favor the big and strong? Is this not the nature of the competitive race? I can only say that in policy matters acceptability and feasibility is of some importance. Further, in our society with its giants of economic power, we are coming to recognize that the public interest and economic efficiency are not always promoted by giving the "natural forces" of competition free reign. We also have precedent in the Farmers Home Administration and the Small Business Administration for such equalization of opportunities.

people without a voice in the management, but the association of the laborers themselves on terms of equality, collectively owning the capital with which they carry on their operations, and working under managers elected and removable by themselves." Ten years later, in 1862, Mill declared that the experience already attained "must be conclusive to all minds as to the brilliant future reserved for the principle of cooperation."[11]

But the future was disappointing. Industrial self-government proved incompetent to organize production and to secure a market. Mill expected the cooperative form of organization to bring about "a moral revolution in society; the healing of the standing feud between capital and labour; the transformation of human life from a conflict of classes struggling for opposite interests to a friendly rivalry in the pursuit of a good common to all; the elevation of the dignity of labour; and a new sense of security and independence in the labouring class!"[12]

Marx was thus not the only one who recognized and was concerned with class conflict. The big difference between Mill and Marx was in the form of innovation in social and economic organization visualized as a cure for society's ills which both recognized. Mill's solution was a peaceable evolution of cooperation. Marx could compromise with nothing less than full-fledged revolution and the inauguration of communism. Yet, as history has shown us, neither the proposed solution of Mill nor that of Marx has been very successful as a major organizational form in Western economics.

Current with the predictions of these two great social critics, the modern corporation was emerging. It has since grown to an overwhelmingly dominating position, and has exhibited an extraordinary capacity for growth and survival. Of a slightly later period Ashley states, "Society is feeling its way, with painful steps, towards a corporate organization of industry on the side alike of employers and of employed; to be then more harmoniously, let us hope, associated together—with the state alert and intelligent in the background to protect the interests of the community."[13]

Three choices were apparently available: (1) the revolution-communism prescription of Marx, (2) the evolution-cooperation prescription of Mill, and (3) the course taken by Parliament whereby the procedures, rights and duties of incorporation were re-defined. Parliament took the centuries old idea of a joint-stock association, modified it, and set the stage for a transformation of the capitalistic system.

It is instructive to note that this exemplifies the methods of democratic

[11] Quoted by W. J. Ashley, *The Economic Organization of England* (London: Longmans, Green & Co., 1922), p. 174.

[12] *Ibid.*, p. 175.

[13] *Ibid.*, pp. 190-91.

action. The eventual results of an action may appear revolutionary, but changes in the rules and procedures at a given time are frequently minor. Dahl and Lindblom point out that "Patching up an old system is the most rational way to change it, for the patch constitutes about as big a change as one can comprehend at a time. The ultimate result of 'patching' is a transformation of the social system. Capitalism was only a series of patches on feudalism."[14] And, one might add, the corporate system of today is the result of several patches on the factory system of the late eighteenth and early nineteenth centuries.

Joint-stock companies[15] were formed and chartered by the King at least as early as the 15th century. After England's revolution of 1688, chartering was either "by the sovereign, as before, but under statutes enacted by Parliament, or directly by Parliament by a special act for each company. Not until the middle of the nineteenth century could companies, either in England or America, obtain their charters by merely registering their articles of agreement with a designated officer of the state."[16]

By 1844, certificates of incorporation could be gotten simply, without delay and at little expense. It was in 1844 that the joint-stock company assumed its modern form. The Registration Act of 1844 distinguished the joint-stock company from the partnership by defining it as a "commercial partnership with more than 25 members or with a capital divided into freely transferable shares."[17] Companies registering under the Companies Act of 1844 were granted corporate capacity, including the right to sue or be sued in the name of a public officer. In 1855 limited liability of shareholders became part of the Company Acts. In the event of bankruptcy of the company, shareholders were liable for no more than the amount of their shares. The Company Acts were consolidated in 1862 giving still greater opportunity for obtaining a large number of small contributions towards the increasingly large capital which was becoming necessary under the existing technical conditions.[18] Although there were further modifications and elaborations of these Acts in 1890 and after

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[14] Robert A. Dahl and Charles E. Lindblom, *Politics, Economics and Welfare* (New York: Harper & Brothers, 1953), p. 86.

[15] In Britain's law and census reports, the use of the term joint-stock company is analogous to the use of corporation in the United States. In United States usage, joint-stock company differs from corporation in the very important respect of limited liability as well as other less important characteristics. I shall use the two terms interchangeably. See W. B. Taylor, *Financial Policies of Business Enterprise* (New York: D. Appleton-Century Co., Inc., 1942), Chap. I and II.

[16] *Ibid.*, p. 23.

[17] G. Todd, "Some Aspects of Joint-Stock Companies, 1844-1900," *Econ. Hist. Rev.*, Vol. IV, 1932-34, pp. 46-71.

[18] See W. Cunningham, *The Growth of English Industry and Commerce in Modern Times* (Cambridge: At the University Press, 1912), pp. 816-17.

1900, the basic patterns were set by the Acts of 1844, 1855, and 1862. Principles annunciated in these Acts remain essentially intact today.

The formation of joint-stock companies following the granting of limited liability was very rapid. Between 1856 and 1868, out of 7,056 joint-stock companies formed, 98 per cent were limited liability companies.[19] Over 6,000 companies were registered between 1862 and 1870 and nearly 11,000 in the following decade. Many of them disappeared, but by 1884 there were 8,700 joint-stock companies in the United Kingdom. By 1890 there were 13,000, by 1900 almost 30,000, by 1920 over 79,000 and by 1940 there were 163,556 joint-stock companies in the United Kingdom with a total paid up capital of £6,074,000,000.[20]

What were the major underlying causes which drove businessmen in such large numbers to this form of business organization? Three factors seem to have been of primary importance.

1. *Technological developments.* Efficient utilization of many industrial innovations required large scale organization in production. This called for increasing concentrations of capital and an increasing capital-labor ratio. The corporate form made large capital accumulations possible. Private owners frequently could not raise this amount of capital and the risks of unlimited liability restrained outside investors. This demand for amounts of capital far beyond the ability of a few individuals to furnish forced, in time, the establishment of the principle of limited liability and fostered the rapid growth in the number of joint-stock companies.

2. *The growing bargaining power of labor.* Throughout the last half of the nineteenth century, laborers made great progress in their economic position. Cole points out that between "1850 and 1900 the average real wages, measured in purchasing power, rose at least by 70 and perhaps by as much as 80 per cent."[21]

The corporation made it easier for the entrepreneur to add to the capital of his business without accumulating the needed resources out of his personal savings or profits. This relaxed the pressure to keep down wages at the same time that it made possible the large increase in the employer's own scale of expenditure.[22]

3. *The Great Depression.* The period from the middle 1870's until almost the end of the century has been called the Great Depression. This was the first time that Britain's prosperity and industrial superiority were seriously challenged by the rise of foreign competition. This thirty-year

[19] Leone Livi, "On Joint Stock Companies," *J. Royal Stat. Soc.*, Vol. XXXIII, 1870, pp. 21-23.

[20] See the appropriate numbers of the *Statistical Abstract of the United Kingdom.*

[21] G. D. H. Cole, *A Short History of the British Working Class Movement 1789-1947* (London: George Allen & Unwin, Ltd., 1948 ed.), pp. 266-68.

[22] G. D. H. Cole, *British Trade and Industry* (London: Macmillan & Co., Ltd., 1932), p. 74.

period of generally declining prices combined with several very sharp drops in the price level was very significant in terms of the number of new corporations formed. The available statistics indicate that increased activity in the formation of joint-stock companies followed by a year or two every sharp break in prices.

This was also the period of the combination movement in Britain. From 1880 to 1900 consumer goods industries lost first place, in terms of total production, to the producer goods industries. It is during this same time that increased competition was forthcoming from Germany and the United States, especially in the capital goods industries. The risk and uncertainties created by the "Great Depression" stimulated a demand for limited liability and the joint-stock principle of organization as well as for business combination in an attempt to gain more control over capital, markets, prices and profits.[23]

The existing economic forms of organization (individual proprietorship, partnership, or joint-stock association without limited liability) could not meet the challenge. These institutions simply could not perform the tasks that needed to be performed. By a slight modification of these existing forms, the economic environment was changed sufficiently so that expansion could take place and thereby the challenge presented by technology, higher wages, and lower prices was met. A new patch was supplied.

III. Implications For American Agriculture

What implications can be drawn from this experience which are relevant to the present organizational problems of American agriculture? Obviously, agriculture in the 1960's presents a unique set of circumstances and problems. Attempting to transplant a solution which proved successful in an earlier period is likely to end in failure. True, the similarity of conditions is impressive. Farms are in need of expansion, and for some of the same reasons which pressed for expansion of the factory a century ago: increasing costs, declining prices, and technological advance. *But the significant lesson is that relatively minor modifications of existing economic organizational forms can sufficiently alter the economic environment and thus permit solution of problems which previously appeared insoluble.*

British manufacturing was facing problems which the existing organizational forms could not meet successfully. Marx and Mill saw little hope for solutions under private capitalism. Parliament, however, through modification in the laws of incorporation, made possible changes in economic organization which again permitted successful operation within

[23] Walther Hoffmann, *British Industry 1700-1950*, transl. by W. O. Henderson and W. H. Chaloner (Oxford: Blackwell, 1958).

the changing circumstances of new technologies, higher wages, and lower prices.

The relevant questions are: Is the family farm in the United States doomed as the factory appeared to be in Britain a century ago? Can we modify some existing organizational forms to permit a smoother transition to more successful operation of our farms in this machine age?

There is little question but that technology exists for organizing agriculture in ways other than family farms. Discontinuities in production, dependence on nature, obstacles imposed by the spatial characteristics of land in agricultural production are all being minimized by technological developments in transportation, communication, scientific knowledge of soils and biology, and a general increase in intelligence.[24] Yet, the family farm organization continues to dominate. There is no evidence that farm corporations have been increasing.[25] There are, of course, sentimental attachments to the family farm, and a few states either prohibit or otherwise limit operation of farms by corporations. Nevertheless, it appears that the real reasons for lack of adoption of the corporate form in farming are economic. Present corporation provisions, even with the favorable new tax option of 1958, do not provide a great advantage over family organization in meeting the dual problems of capital accumulation and transfer. We need new provisions and additional modifications before the corporation will provide distinct advantages.

What are the advantages of the corporate form generally suggested? Limited liability? This is of little advantage to a farmer with nearly all his assets in the farm business. Nor is there ordinarily a tax advantage. The 1958 option simply put the small corporation on a basis of tax equality with the partnership. But how about the problems here under consideration: capital accumulation and ease of transfer? At present, the corporate form offers few advantages in these areas.

Let us take an example of a large family farm with about one-half million dollars investment. This is a very small firm in comparison with industrial corporations. This firm cannot reach the impersonal financial markets with its stock. Owing to small size, the biological nature and diversity of agricultural production, and the wide range in levels of management, there is a lack of communicable knowledge of the kind required for drawing funds from outside the local community. In industry generally the opposite holds: large size, nonbiological standardized production, and a fair degree of uniformity in high quality management. The

[24] I believe conditions have changed sufficiently to warrant a new interpretation from that given by John M. Brewster in "The Machine Process In Agriculture and Industry," *J. Farm Econ.*, 32:69-81, Feb. 1950.

[25] John M. Brewster, "Technological Advance and the Future of the Family Farm," *J. Farm Econ.*, 40:1596-1609, Dec. 1958.

mere fact of incorporation does not expand the fund raising ability of the farm enterprise we are describing.

Is it likely that this firm could obtain finances more readily from local investors? This, too, is doubtful. To compensate for the risks and the limited marketability and liquidity of the stocks, investors would probably require a higher dividend return than farmers could pay. They might also demand or obtain more control than the farm family could give up and continue as a family farm. In a closely held corporation the principal stockholders often are required to incur personal liability by endorsing corporate obligations in their individual capacities. Hence, this small corporation is still essentially restricted to family investors and the use of traditional instruments for borrowing.

Now let us suppose that one of these stockholders wishes to dispose of his stock, to whom can he sell it? Very likely only to the other existent stockholders. This brings up the problem of transfer. Does this small, closely held corporation facilitate such transfer?

Undoubtedly in certain cases the corporate form can serve as a means of transferring ownership gradually to the son. Also, if there are other children heirs, they can draw their inheritance in the form of stocks. But these young people will want to purchase homes or businesses of their own. In many cases they will want liquid funds. How can they convert their stocks? Can they sell them to a stranger or to a city banker? Not likely. Again, they must turn to the present stockholders or some local person or firm well acquainted with the farm operation.

The fact of the matter is that the small size, the biological nature and diversity of agricultural production, and the wide range in levels of management result in a lack of communicable knowledge and thereby restrict access to funds to a local level. This limits the effectivness of the corporation as a means both of capital accumulation and transfer. Thus, provisions of the corporate form of economic organization need modification before they can become effective instruments in agriculture.

IV. A Proposal For Modification of the Corporate Form to Meet the Needs of Agriculture[26]

How is this to be done?

This is a complex undertaking and requires much more study than I have been able to devote to it. The following suggestion is tentative. It is my hope that it will stimulate discussion and research on this very important question.

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[26] Some of the ideas in this section were suggested by Professors Jake Buescher and August Eckhardt of the University of Wisconsin Law School. I wish to acknowledge their assistance, but responsibility is, of course, mine alone.

The basic requirement is construction of a market for corporate stocks issued against farm property organized in relatively small units and managed and operated by one or several families. One possibility is setting up a new governmental agency to purchase these stocks. Another possibility is to modify the present function of the Federal Land Banks permitting them to purchase the stocks. (Hereafter I shall refer to this institution, whether a new agency or existing Land Banks, as the agency.)

Existence of such an agency would give the farmer or the nonfarm heir the option of investing in or selling his interest in the farm. For example, if and when a farmer chooses to incorporate, the farm property could be represented by stocks of varying dollar amounts—let us say $100 to $1,000 in even hundreds. These stocks could be identified with a specific farm corporation and could be sold to the agency. The agency in turn would sell its own securities on the financial markets. These would not be identified with any specific farm but only with the agency. The corporation could subsequently repurchase the stock from the agency, or it could continue indefinitely to pay a specified dividend to the agency. In other words, the agency would hold preferred rather than common stock.

This is not greatly different from the idea of the agency holding a very long term or essentially permanent mortgage. In this case, each generation would assume the mortgage of the former and continue to pay interest and installments. The advantage of the present proposal is in the transfer of large aggregates of capital to several heirs. Since the physical property cannot be divided, issuing of shares permits smooth and equitable transfer. The holder of such stock would have a ready market. In addition, the corporation could more easily obtain additional credit from traditional sources if the agency held preferred stock rather than a mortgage.

The agency could be protected by an insurance scheme which could be built into the stipulated dividend rate. This rate could be graduated to reflect the proportion of a corporation's stock held by the agency. In effect, this would be a risk premium added to the going rate.

The law providing for the establishment of the agency could stipulate that only farm corporations could deal with the agency. By-laws of the corporation could specify that it would always stand ready to purchase the stock of individual stockholders. Also, individual stockholders would hold common stocks with residual claimant rights. Since the agency would hold preferred stock, this would be an additional protective feature for it. An individual wishing to dispose of his stock could sell it to the corporation which, if it desired, could issue preferred stock for sale to the agency. This would be a protective feature for the corporation in that it would at all times be aware of new obligations in the form of fixed commitments of preferred stock.

This would not be a competitive market. Therefore, certain regulations would have to be built into the procedures. Thus, the farm would have to be appraised by the agency at the time it was requested to purchase stock. The fee for such appraisal would have to be borne by the corporation.

The agency could be protected further in the following manner. If it owned a specified proportion of the stock of a given corporation, the corporation would have to comply with certain regulations to assure future productivity and value. It would also be reasonable to stipulate a maximum percentage of appraised farm value above which the agency would not purchase a corporation's stock.

Who would be eligible to avail themselves of this new market in farm corporation stocks? To protect the corporation, only it would be permitted to repurchase the stock from the agency. It would then be free to sell or grant it to individuals.

There is a problem of potential inflation in land prices inherent in such an arrangement. Yet, presumably this would be met much as it is met today. An objective appraisal by the agency would determine the market value. And if the agency decided that the management did not have the ability nor the firm the potential for reasonable expectations of success, then presumably it would not make its services available. In other words, it would ration capital much as bankers do today.

This tentative suggestion of modifiying the corporate provisions is only one alternative to meeting the needs of capital acquisition and facility in transfer. Undoubtedly there are other ways in which these needs could be met. More thought and research effort by economists and lawyers should be devoted to such alternative possibilities. We need become more concerned with social inventiveness.

V. Conclusion and Suggestion for Research

What is here suggested is essentially an improvement or further extension of the farm credit system. It is a suggestion for adaption of a form applied for many years in the industrial sector.

Britain solved her problem of a century ago by modification of the provisions of the age-old joint stock association. The present proposal would modify the provisions of the century-old corporation. The resulting institution would, I suppose, be a kind of hybrid. But it could, and likely would, have most of the features of the large family farm existing today. And Congress, it appears, wants to preserve such features. Given the present circumstances in agriculture, it may well be that the only way to retain organizational features akin to the family farm of today is through some modification of procedures for capital accumulation and transfer.

Whether or not this specific proposal is workable is, at the moment, of little importance. *The important point is that agricultural economists provide some creative thinking and intellectual leadership on this crucial problem!* To date it has virtually been neglected in the research and discussions on agricultural policies and the "farm problem." Why is this? It appears to me that most research efforts have been directed at modifying "undesirable" results (price-income) without sufficient attention to the economic and social arrangements (organization) under which these results occur.

Organizational change cannot be realized by passing a law requiring the change. Yet "desirable" performance is inextricably bound to organization. In democratic societies, such change is usually brought about by modification of the rules and procedures of existing forms. Such modification is essentially permissive rather than compulsive. It permits individual participants, through voluntary choice, to change the system over time. For this orientation to the analysis of agricultural policy issues, the writings of the late John R. Commons are most relevant.[27] His analytical focus was the organizational, institutional arrangements underlying the commodity, price, income results. Today we tend to focus on the results and ignore the underlying organizational features. It seems obvious that what we need is a combination of these two analytical approaches.

I am not suggesting nor do I have any illusions that alleviation of the organizational problems will "solve" the price-income problem. In all probability, the essential structural differences between agriculture and industry will remain about as they are at present. Agriculture will remain dependent on some form of governmental regulation and support. But the price-income problem and supply control will, I believe, become more manageable and create less frictions after provisions for organizational change are instituted.

Evidence on these points can only be obtained from studies of actual situations. It would, for example, be useful to know the magnitudes of capital accumulation and the procedures whereby this accumulation has taken place on the larger units in different types of farming areas over the past several decades. Likewise, what kind of transfer arrangements have been worked out in transferring these large units? To what extent does the increasing age of operators indicate difficulty in transfer?[28] What has

[27] John R. Commons: *Legal Foundations of Capitalism* (Madison: Univ. of Wis. Press, 1957), and *Institutional Economics: Its Place in Political Economy* (Madison: Univ. of Wis. Press, 1959).

[28] For example, in 1930 over 23 per cent of farm operators were under 35 years of age; in 1954 this percentage was 15. In 1930 slightly over 28 per cent were over 55 and by 1954 almost 40 per cent were over this age. U. S. Dept. Agr., *Family Farms in a Changing Economy*, Agr. Info. Bul. No. 171, March 1957, p. 31.

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been the experience of actual farm corporations in capital acquisition, sale and transfer of stock? Have they been limited to family members or close friends? What has been the trend of tenure patterns within different commercial-size farm classes in different types of farming areas? To what extent has expanded volume of sales on large farms been due to intensification and to what extent to farm size expansion?

These are questions well adapted to regional research undertakings with USDA and University cooperation. It is only as we get more information on these matters that we can be more specific regarding required institutional change. Such changes are bound to come with or without the advice of economists. The question is whether or not economists can help to shape and direct them so they will be most beneficial to the public welfare.

RURAL LOCAL GOVERNMENT IN SPARSELY POPULATED AREAS

CLARENCE J. HEIN
Agricultural Research Service

DURING the last 10 years, there has been a revival of interest in local government, sparked in part by the obvious difficulties of many local units in supplying the services needed by their citizens. A number of recent studies of local government indicate that the difficulties have increased since the 1930's, when agricultural economists and State agricultural experiment stations produced a number of basic studies of rural local government, and that many of the problems remain unsolved.[1]

This article examines the development of rural local government in sparsely populated areas, the problems discovered, and the solutions suggested two decades ago. It suggests also some hypotheses about the lack of acceptance of these "solutions," and some needed research aimed at the resolution of both the old and the more recent difficulties of rural local government.

The basic cause of recent difficulties of local government might be described as an increase in and an upgrading of the demand for governmental services. The demand has three aspects: More people require government services, people want a higher level of services than they have received in the past, and they require more kinds of governmental services. Many of these requirements have been the result of technological changes. Some of the increased requirements for government services caused by changes in the use of the automobile illustrate this upgrading of demand. First, more people have automobiles, so more and wider highways are needed. Second, owners of automobiles expect better highways—hard-surfaced, smoother, safer highways. Third, improvements in the automobile enable more people to travel farther in their leisure time. The latter has been a factor in the increased demand for such recrea-

[1] Among the recent studies concerned with county government, for example, are: Donald E. Boles and Herbert C. Cook, *An Evaluation of Iowa County Government*, Ames, Iowa, Iowa College-Community Research Center, 1959; *Report of the Illinois County Problems Commission to Governer William G. Stratton and the 71st General Assembly*, March 1959; "Alternative Forms of County Government," Sec. 3 of *Selected Metropolitan Area Problems*, Staff Res. Rept. No. 34, Ohio Legis. Serv. Commn., Columbus, Feb. 1959; and *County Government and the Problems of Urban Expansion*, Madison, Wis., Bu. of Govt., Univ. of Wis. Ext. Div., March 2, 1959. In addition, many studies of local government in metropolitan areas have been conducted, including the areas surrounding St. Louis, Mo.; Cleveland and Dayton, Ohio; Los Angeles, Calif.; New York, N. Y.; Philadelphia, Pa.; Miami, Fla.; Baton Rouge, La.; and Toronto, Canada.

tional facilities as public parks, lakes, beaches, and forests. These are, of course, only a few of the changes brought about by the automobile.

The increasing demand for governmental services has placed considerable pressure on rural local governments to provide adequate schools, highways, hospitals, fire protection, recreation facilities, and many other services. Because more and better services require higher expenditures, costs of local government have risen, placing considerable strain on local tax sources. In many areas, it has become increasingly apparent that the existing organization of local government is not adequate to supply the required service, and some adjustments have been begun. The consolidation of school districts is an example, although many districts are still too small to provide adequate educational opportunities.

Despite these adjustments, it is apparent that the problems of local government are increasing and that existing local governments, which were designed to meet the requirements of the 19th century, may not be the best organizations for meeting the demands of the 20th century.

Too often, in the past, the basic problem of rural local government has been regarded as a question of how to provide a minimum of governmental services as cheaply as possible. Rural residents, it was thought, did not need the "frills" available to city residents, such as running water piped into their houses and hard-surfaced streets running past their doors. Education for rural residents, too, did not need "frills," because one could learn to be a good farmer without ever attending school. Today, the managerial qualifications needed by the commercial farmer often are higher than those of the managers of business enterprises in the neighboring cities, and the need for improving rural education can be more readily seen.

Today, then, the basic problem of rural local government is both one of improving the services that have been provided in the past and one of providing the new services demanded by the citizens. Rural residents are no longer satisfied with a bare minimum of governmental services. In addition, changes in technology have made possible a higher standard of living, requiring a higher standard of governmental services. More and better public services not only cost more money, requiring increased revenues for local governments; they may also require some considerable changes in the operation of rural local government.

This basic problem can be seen most clearly in the sparsely populated areas, in which it is not obscured by the sheer numbers of citizens found in the rural-urban fringes of metropolitan areas, where local governments have the additional problem of a rapidly increasing population needing expanded services. To understand the present problems of sparsely

populated areas, it is necessary to trace briefly the development of the system of the rural local government there.

Rural Government in Sparsely Populated Areas

For the purposes of this article, a sparsely populated county is defined as one with a population density of less than 16 persons per square mile, or with less than 5,000 total population.[2] The accompanying map shows the location of the counties in the United States that meet this criterion. There are 807 of them, slightly more than 26 percent of all the counties in the United States. While these counties are scattered throughout the country, the concentrations in the West and the Great Lakes States are noticeable.

The development of our institutions of rural local government in the United States usually followed a pattern of borrowing from the system used in States established earlier. The men who set up the system of local government in each new State usually adopted the institutions with which they had become familiar in the States from which they had come, and as local government was extended into more and more parts of a new State, the tendency was to try to use the same kind of local government in all parts of the State. The attempt to introduce the pattern of Congressional townships and small common school districts into the forested areas of northern Michigan, Wisconsin, and Minnesota has received considerable attention because these local government units were found to be unsuitable despite the fact that they worked reasonably well in the southern parts of these States, where the land was better suited to agriculture. The failure of the traditional type of local government in timber areas resulted in the pioneering efforts at zoning of rural lands for forest and recreation use only, under the joint leadership of local officials and the agricultural economists and their colleagues at the State Agricultural Colleges.[3]

[2] There is no accepted definition of a rural county, and hence no starting point for defining a sparsely populated rural county. One possibility appears to be to take every county that has no "urban" population according to the census definition of urban places as those containing 2,500 or more inhabitants. However, this definition would include many counties in more densely settled rural areas. The definition used here is arbitrary but takes into account population density and total population, which appear to be the two primary measures available. For another definition of rural counties, see U. S. Dept. of Health, Education, and Welfare, *Statistics of Local School Systems:* 1955-56 (Washington: U. S. Govt. Print. Off., 1959), Rural Counties, Chap. 3, Sec. IV, pp. 1-6.

[3] Although there is a considerable body of literature on these developments, the essence of the changes in rural local government which resulted from this movement are described in Walter Rowlands, Frank Trenk, and Raymond Penn, *Rural Zoning in Wisconsin,* Wis. Agr. Expt. Sta. Bul. No. 479, Nov. 1948; in *From Public Burden*

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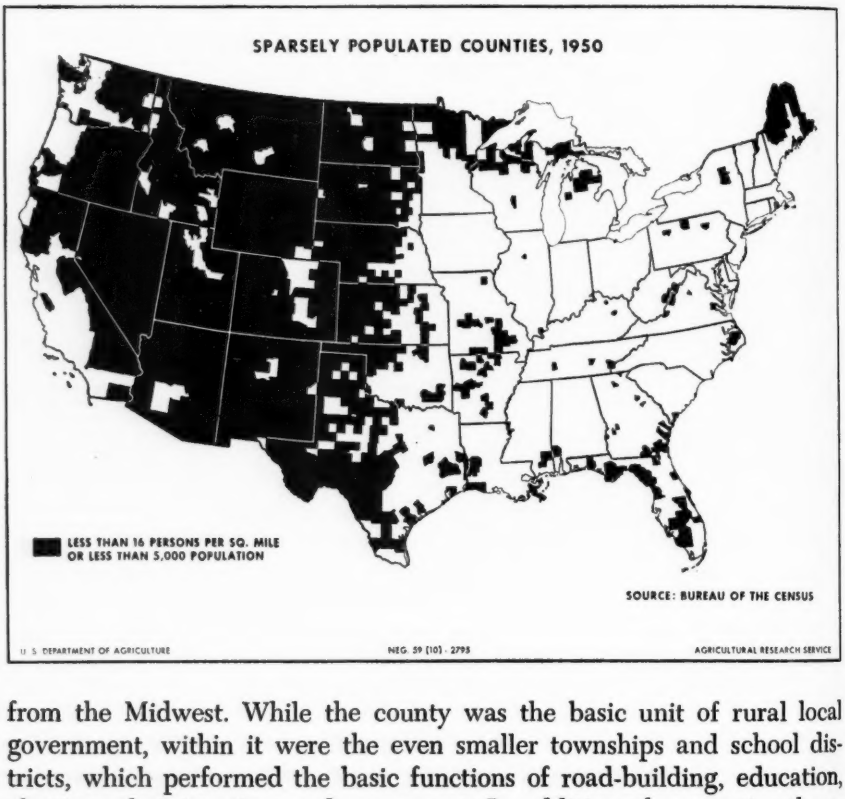
Similarly, in the Great Plains and Mountain States the scheme of local government organization was brought in from the States from which the settlers came. Since these western States were settled from different directions and at different periods of time, local government organization varies from State to State.

The Northern States through which the eastern boundary of the Great Plains passes—North Dakota to Kansas—were settled primarily by people


SPARSELY POPULATED COUNTIES, 1950
LESS THAN 16 PERSONS PER SQ. MILE OR LESS THAN 5,000 POPULATION
SOURCE: BUREAU OF THE CENSUS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 59 (10) - 2795
AGRICULTURAL RESEARCH SERVICE

from the Midwest. While the county was the basic unit of rural local government, within it were the even smaller townships and school districts, which performed the basic functions of road-building, education, election administration, and assessment. In addition, the counties themselves were small because of the familiar requirement that a farmer ought to be able to travel to the county seat, transact his business, and return home all within one day.

States that were settled by emigrants from the South did not have

to Public Benefit: The Story of Marinette County's Land Program, Wis. Agr. Expt. Sta. Bul. No. 483, Jan. 1949; and in Raleigh Barlowe, *Administration of Tax-Reverted Lands in the Lake States,* Mich. Agr. Expt. Sta. Tech. Bul. No. 225, Dec. 1951.

townships, but counties tended to be small and school districts were smaller and more numerous than the counties.

The Western Plains and Mountain States were settled later; they have larger counties, fewer school districts, and no townships. Local government organization was developing in response to the pattern of land use, as experience in the eastern Great Plains demonstrated that small units of local government were not adequate to the needs of this sparsely populated area.[4] Space was making itself felt as a factor in determining local government organization.

The general trend in rural local government in the United States in the last 60 or 70 years has been toward larger units of government. The progress in consolidation of school districts in recent years is well known, with the 1957 Census of Governments reporting a decline from 108,579 to 50,446 school districts in the last 15 years.[5] Townships have not shown so large a decline in numbers, but have suffered a steady atrophy of activities as one function after another has been assumed by the county or some other larger unit of government.[6]

For urban places, there have been contrasting trends. Scattered throughout the sparsely populated areas were small platted villages which, it was hoped, would grow first into small cities and then into large ones. The hopes of the early settlers were not always realized, and a solitary stone monument along a rural road may mark the site of a village which once competed vigorously to become the county seat, but was bypassed by the railroad builders and has since disappeared. Other villages at which trains no longer stop are in the process of disappearing, as are some of the villages that were made obsolete by the building of all-weather highways and improved automotive transportation.

Some of the early villages survived to become thriving trade centers for the agricultural areas around them, and a few grew into cities—not large cities by metropolitan standards but distinctly urban in their way of life. Here again, the trend seems to be toward larger units. The larger cities have been growing more rapidly than the smaller ones in most of the sparsely settled areas.[7]

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[4] For a critique of the introduction of humid area governmental patterns into the Great Plains, see chapter 13, "Unsuitable Governmental Institutions for the Plains," in Carl F. Kraenzel, *The Great Plains in Transition*, Norman, Okla.: Univ. of Okla. Press, 1955.

[5] U. S. Bu. of the Census, *1957 Census of Governments*, Vol. 1, No. 1, "Governments in the United States," U. S. Govt. Off., Washington, D.C., 1957, p. 1.

[6] Drury, James W., *Township Government in Kansas*, Univ. of Kan. Governmental Res. Ser. No. 10, Lawrence, Kan., 1955.

[7] See John C. Ellickson, *Farming in the Great Plains*, U. S. Agr. Res. Serv. (in press), ch. II, for a discussion of population trends in the Great Plains.

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One further trend in local government—the increased use of special districts—has been noticeable. These units of government are usually authorized to perform one particular governmental activity, although in a few instances multi-purpose districts have been authorized. In rural areas, examples of special districts are irrigation, drainage, conservancy, fire protection, soil conservation, flood control, cemetery, and library districts. The use of these special districts indicates a belief that existing local governments could not perform the required services.

Trends in local government in the sparsely settled areas do not as yet reflect the full impact of economic and social changes that have occurred in these areas. Developments in technology, transportation, and communication have brought about tremendous changes in land use and in the farmers' and ranchers' way of life. The gradual disappearance of the distinction between urban and rural residents that has been noted in other parts of the United States is also evident in the sparsely populated rural areas. Farmers and their wives, daughters, and sons, are no longer distinguished from their urban cousins by their clothing, their mode of transportation, or the presence or absence of electric refrigerators, stoves, and garbage disposals in their kitchens. In fact, there is some indication that farmers and ranchers have adjusted more readily to technological changes than have the residents of neighboring villages and small towns.[8]

In sparsely settled areas, the problems associated with sheer space became noticeable much earlier than in the more densely settled areas, where the economic and social costs of the space used by urban expansion and suburban sprawl has only recently demanded serious attention. The cost of providing governmental services to rural residents separated by large distances from their neighbors has long been noted.[9]

One solution to the economic and social problems caused by the space factor is that the farmer has moved to town, or maintains two residences, one in town and one on his land. In some areas of western Kansas it is estimated that between 30 and 40 percent of the farmers and ranchers live in town,[10] and commute to work just as do the residents of metropolitan areas. Educational, social, and recreational services are more readily available to the farmer and his family under this arrangement, and transportation costs are less than they would be if the family lived in a rural residence.

Another new residential pattern that helps to minimize the social and economic costs of space is the "string" community, in which rural resi-

[8] Kraenzel, *op. cit.*, p. 333.

[9] A. H. Anderson, "Space as a Social Cost," *J. Farm Econ.*, 32:411-30, Aug. 1950, and Kraenzel, *op. cit.*, p. 322.

[10] Warren R. Bailey, "Land and Problems in the Wheat Regions," in *Land*, U. S. Dept. Agr. Yearbook, 1958, p. 153.

dences are concentrated along a few hard-surfaced roads, in contrast to the "grid" pattern prevalent in the more humid areas.[11] Where residences are relatively concentrated along a few roads, it is obvious that the costs of mail delivery, school bus transportation, snow plowing, REA lines, and similar services are reduced.

Seldom, however, has there been any comparable change in rural local government that indicates recognition of either the changes in residential patterns or the need for governmental encouragement of these kinds of changes.

In addition to the direct population growth of villages and cities which is accounted for by this movement of farm families to town, a substantial part of the population growth is caused by technological and economic changes in the life of the farm family. City residents are needed to sell, order parts for, and repair the machinery which technological change has provided for farm use. This is true also for the refrigerators, electric stoves, and similar appliances found in the residence of the farm family. The fact that one farmer supplies food and fabric for an increasing numbers of nonfarm people has been widely noted; the allied fact that increasing numbers of nonfarm people are needed to supply products and services to the farmer has received less attention. The individual farmer has become more important in rural areas as a consumer of goods and services, although in many of these areas the total number of farmers has been decreasing.

Past Proposals for Up-Dating Rural Local Government

While technological and economic developments have resulted in major changes in the practices and lives of the farmer and his family, their local institutions of government have changed more slowly and less drastically.

Apparently, the slowness of governmental change has not been due to any lack of study of rural governmental problems.[12] The bulk of the rec-

[11] Anderson, *op. cit.*, p. 426.

[12] A complete listing of the studies of this problem by agricultural economists alone would take up too much space. The following partial list serves to indicate the quality of the investigators and their work: George S. Wehrwein and Bushrod W. Allin, *Possible Farm Tax Reduction Through Changes in Local Government*, Wis. Agr. Expt. Sta. Spec. Bul., March 1933; Fred A. Clarenbach, *Needed Local Government Reorganization in Ozark Land Use Adjustment*, Mo. Agr. Expt. Sta. Res. Bul. No. 331, 1941; J. Lloyd Spaulding, *Farm Taxes and the Costs of Public Services in Relation to Land Resources in Ringold County, Iowa*, Iowa Agr. Expt. Sta. Res. Bul. No. 288, June 1941; Peter L. Hansen, A. B. Goodman, and Morris H. Taylor, *Local Government in Southwestern North Dakota*, N.D. Agr. Expt. Sta., May 1943. Similar investigations have taken place since 1943, and currently others are being conducted in a number of States, both by agricultural economists and political scientists.

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ommendations for changes in local government organization made by the numerous studies of rural local government problems during the last 30 years may be summarized in three groups: (1) The minimum area for local government units should be larger; (2) there should be fewer elected officials; and (3) local citizens should have a choice between a number of alternative forms of local government.

Larger areas

Suggestions for increasing the minimum area of local government units are based primarily on the premise that this will enable the local unit to carry out its functions more economically and efficiently. Most frequently advanced are proposals for the abolition of townships, the consolidation of school districts, and the consolidation of counties.[13]

The abolition of townships is urged on the grounds that they are too small in area to perform effectively the governmental functions assigned to them. For example, in those areas where they are not completely dormant, the most important function of townships is often the provision of rural roads. Proponents of their abolition argue that townships are too small in area to make effective use of modern road machinery, and that this is illustrated by the fact that counties and the State usually provide the more important rural roads. It is also suggested that the unit providing roads should be large enough to make use of the services of a full-time highway administrator who is a professional engineer. Similarly, it has been urged that townships are too small a unit for assessment purposes, and that more effective and efficient assessment will require a unit large enough to keep at least one professionally trained assessor occupied on a full-time basis.

Despite the apparent force of these arguments, not very many townships have been abolished in the last 15 years. In 1957, there were 17,198 townships and towns in the United States. The comparable figures for 1952 and 1942 are 17,202 and 17,311 respectively.[14] Apparently, what has happened in the case of the townships is that many of the functions and services performed by these units in the early part of the century have

[13] A noteworthy exception to this is Clarenbach's suggestion that consolidation of counties in the Ozark region of Missouri would not really solve any problems because it would be only a "consolidation of weakness." He suggested that improved State supervision of counties and intracounty reorganization are preferable to consolidation. Clarenbach, *op. cit.*, p. 27.

[14] *1957 Census of Governments,* Vol. I, No. 1, pp. 1, 11. The figure for 1942 does not include the 1,608 townships in Iowa which the Bureau of the Census later decided did not meet the criteria of units of government because of their extremely limited activity and discretion. They also were not included in the enumerations for 1952 and 1957.

been transferred to larger units of government by statute. Thus, compared with their former importance as governmental units, the townships are more or less empty shells.

In New England, in most instances the town has retained its earlier functions, although even here there has been an assumption of some of the functions by a larger unit, usually the State itself. In some other States, townships have been authorized to provide an increasing number of services and have become in effect a type of municipality. This is widespread enough so that in reporting township revenues, the Bureau of the Census differentiates between States with "rural" and "major" type townships.[15]

The record with regard to consolidation of school districts, of course, is considerably better. Between 1942 and 1957 the number of school districts was cut by more than half.[16] This decline in numbers has been the result of a persistent campaign on the part of professional educators, government officials, and citizens' groups to obtain school units large enough to support an adequate educational program. Although there is not complete agreement as to the standards by which an adequate education is measured, there is general agreement that it is more difficult to provide in very small schools. Conant has suggested that the minimum sized high school that can provide the kind of education needed for the challenges of the space age would be one with a graduating class of at least 100.[17] A unit of government that could support this kind of high school would be considerably larger than most of our present rural school districts.

The suggestion that counties be consolidated has met with even less success than the suggestion that townships be abolished. The Census of Governments reports a decline of three in the number of counties between 1942 and 1957.[18] Despite this fact, in recent years the need for an increase in the area of counties has been re-emphasized even in the Western States, where counties are larger than in other parts of the

[15] *1957 Census of Governments,* Vol. III, No. 3, p. 7. The States with "rural" townships are Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Washington. For a recent summary of the problems of the New England towns, see John P. Wheeler, "Towns in Transition," *National Civic Review,* Feb. 1959, pp. 68-72.

[16] *1957 Census of Governments,* Vol. I, No. 1, pp. 1, 11.

[17] James B. Conant, *The American High School Today,* New York: McGraw-Hill, 1959, pp. 14, 38.

[18] *1957 Census of Governments, loc. cit.* Since that time, the Connecticut legislature has abolished the 8 counties in that State, and the Wisconsin legislature has established the new county of Menominee. So far as is known, there have been no other changes, although the consolidation of two counties in South Dakota is under active consideration.

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country.[19] In support of the suggestion for larger counties, the old rule-of-thumb that a resident should be able to get to the county seat and home in the same day would indicate that a maximum distance of 80 to 100 miles to the county seat would not be unreasonable.

Fewer elected officials

Suggestions for reducing the number of elected officials are also usually based on the premise that more economical and efficient local government would result from this change. With each of 8 or 10 separately elected officials independently carrying out his part of county government, no one is really responsible for the conduct of county business. The county governing body has control of only part of the activities of the county. Presumably, if more offices were made appointive, the county board might become the legislative body for a more unified county government.

Some of the suggestions for changing from elected to appointed officials are based on the need for more professional competence in the performance of many county duties. The proposal to replace the elected coroner by an appointed medical examiner is an example of this type of suggestion.

A suggestion that comes most often from sparsely populated counties is that two or more of the elected offices should be combined. For example, the county clerk can perform the duties now assigned to the register of deeds and the county treasurer in some counties, thereby eliminating the need for having the latter two offices filled by election. Evidence from the sparsely populated areas indicates that the workload in some county offices is low enough so that this kind of consolidation would result in greater economy and efficiency.

Alternative forms of county government

Another group of suggested reforms concerns the provision of different forms of county government. The alternatives most frequently suggested are a county manager system similar to the city manager form of government, and a county executive form, which is comparable to the "strong mayor" form in cities. In both instances, there would be a considerable unification of policy-making and administration in the hands of the county board and an appointed manager or an elected chief executive.

In some States, the legislatures have long been unwilling to authorize

[19] G. Homer Durham reports a suggestion that Utah counties be reduced in number to 6 from the present 29, in "Consolidation in Utah Local Government," *The County Officer*, 18:243-45, 256. See also Roland R. Renne, *The Government and Administration of Montana*, New York: Thomas Y. Crowell Co. 1958, p. 438.

the use of alternative forms of county government. Even when the alternative forms are authorized by statute or constitution, there have been few changes from the older form of county government. The number of counties with a county manager form of government meeting the standards of the International City Managers Association has increased from 6 in 1940 to 18 in 1959, still a not very sizable proportion of the 3,040 counties in the United States. In addition, at least 32 counties have some sort of county administrator system that is similar to the county manager plan, and 7 counties have an elected executive officer.[20] One may conclude that there has been considerable resistance to accepting the suggestion that alternate forms of county government be used.

Very few rural counties have adopted a newer form of county government. The notable exception is Petroleum County, Montana, which has used the county manager system successfully since 1943. It has not been adopted by any other sparsely populated rural county in Montana or elsewhere despite considerable evidence that county government in Petroleum County has operated more economically since adoption of the county manager system.[21]

Over the last 25 years, then, the proposals advanced for reorganizing rural local government have met with little success. The consolidation of school districts is a partial exception to this, but even in the case of these units, the goal of an adequate district probably will not be attained very soon in those States where the number of school districts is still large. Most other units of local government are the same size they were in the 1930's, when they were judged to be too small. Very little consolidation of offices has occurred within the local units, and the form of government used by our rural local units also has changed very little.

Perhaps some of the lack of acceptance of the major suggestions of past studies of the problems of township and county government may be explained by their too narrow focus on a limited economic aspect of local government: how can present services be provided more efficiently and economically?

The relative success of the movement for school consolidation may have been due partly to the emphasis placed on providing an adequate education for all children in the area rather than on the economies that might result from consolidation. Some of the success of this particular movement, of course, is due also to the activities of well-organized interest groups in support of the proposed changes.

[20] Ohio Legislative Service Commission, *Selected Metropolitan Area Problems*, Staff Res. Rept. No. 34, Feb., 1959, pp. 49-50.

[21] Roland R. Renne, "Montana Pace Setter," *National Municipal Review*, 47:115-118, 131 (March 1958).

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Needed Research on Problems Affecting Rural Local Government

Assuming that the recent revival of interest in local government problems indicates a desire for effective local government and a willingness to take a fresh look at proposed solutions to the problems, what can be done to adapt our local governmental institutions to the changing economy and society of our rural areas? Much additional research is needed to provide alternative solutions to present and emerging problems in our sparsely populated areas. It is clear that a solution to most of these problems requires a considerable degree of State and local governmental activity, in cooperation with or as a supplement to private action. In many instances, governmental authority is needed to make a cooperative plan successful.

Because the number and complexity of the problems facing local governments in sparsely settled areas has increased, the traditional organization that was suited to the 1890's will need to be modified. Although many people realize that farming today differs vastly from what it was in their youth, apparently they are slow to recognize the resulting need for changes in government organization and services. The important question that now faces rural local government is not *whether* it will change, but *how* it will be changed.

A whole host of problems for local government have been set in motion by the changes in technology which make larger farms necessary to employ adequately the capital invested in equipment and machinery. For example, fewer opportunities to become farmers means that more young people will leave in search of opportunities to earn a living. Whether they stop at the nearest town, or at a nearby small city, or go on to larger cities farther away, the movement raises problems for local government. Their departure means that the proportion of older people in the population that remains is higher, a fact which provides additional problems for local governments. The underemployment of rural labor and an understandable desire to keep people from leaving the community has led to rural development programs, and these programs also require local government activity, often in new and different directions. Also, experience has indicated that one of the criteria by which desirable prospective industries judge a community is the adequacy of the services provided by local government.

From among the many problems facing rural local government as a result of changes caused by technological forces, three have been selected to illustrate briefly the extent and variety of needed research. These are (1) health and hospital services, (2) recreation, and (3) economic development. It should be emphasized that many other activities of local government have equal or greater problems.

One specific problem on which social and economic changes bear is that of health and hospital services. Technological change and increased specialization in medical services have helped to cause the disappearance of the family doctor from some of our rural areas. Many residents of sparsely settled areas do not as yet have access to the kind of modern medical services available in our larger cities. Considerable research is needed to determine the costs of providing adequate health services, how these costs can be paid, and the kinds of voluntary and governmental activities that can best provide adequate health services. Many individual communities have experimented with economic and social action to induce a doctor to settle in the community. Other communities have built hospitals with various degrees of complexity and specialization. What are the economic and social costs, both for communities that have taken the initiative in these matters and for those which have no medical care or inadequate hospital facilities? Does this kind of competition between communities provide the optimum of health services, or would some kind of cooperative endeavor maximize the available services? What organization and activity on the part of local or State governments has been most helpful in providing adequate health services? Have hospitals been overbuilt in some areas, and how might this be avoided in the future? What are the economic effects of building a hospital in one town or city or in another? Are adequate health services economically feasible in sparsely populated areas? What kinds of special economic, social, and governmental problems are posed by the special health needs of the growing proportion of older people in sparsely populated areas? How can the costs of these needs best be met? These are only a few of the questions that need to be answered before the proper role of local government in solving problems of health and hospital services in our sparsely populated areas can be determined.

A second problem area is recreation, which is beginning to receive attention. The fishermen and speedboat enthusiasts on a newly built reservoir in a remote location in a sparsely settled area are testimony that a previously unmet recreational need has become a social and economic reality. In other areas, natural features provide or could be developed to provide recreation facilities for both local residents and for tourists. What type of governmental aid and supervision is needed for optimum development of recreational resources? What additional demands for governmental services are generated by certain types of recreational facilities, and who should bear the costs of the added facilities? In what circumstances can the development of a recreation industry add to the economic well-being of the community? What additional types of recreation are required to induce young people to remain and needed

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professional people to settle in a community? Since people can and do travel considerable distances to recreational facilities, what kinds of voluntary or intergovernmental cooperation can be used to provide area-wide facilities?

A third group of problems for local communities is posed by economic development, and attempts to induce such development. There are few cities or villages so small that they do not suffer from undesirable ribbon development along the major highways just outside the city limits. In many instances, a more suitable location would benefit the business and make it a welcome addition to the economy of the community. Yet, relatively few local governments have established policies for providing suitable locations for business or industry needing ready access to highway transportation facilities. To the extent that commercial and residential ribbon developments are caused by a desire to escape taxation or certain types of government regulation, it seems that either the taxation and regulation are undesirable or that reorganization of local government is needed to insure that desirable regulations cannot be escaped.

Many of the same questions arise when attempts are made to induce an industry to establish itself in the community. What are the long-range economic and social effects of tax subsidies, economic subsidies, or exemptions from local regulations for new industries? If an industry is unwilling or unable to pay its own way, what are the economic effects of letting it settle in a competing community? Since studies indicate that residential areas occupied by people in the lower income brackets tend to require more in the costs of government services than they pay in taxes, the long-range effects of acquiring industries that pay minimum wages needs to be explored more fully. Under what circumstances can an industry be expected to pay the full costs of governmental services for its employees and their families? Under what circumstances can a community benefit from subsidizing part of these costs for certain industries? Until there is more information about these problems, it will be difficult to frame adequate local government policies concerning economic development.

The list of questions can be expanded almost indefinitely, and the questions that have been asked suggest additional questions for research. However, the illustrations that have been given should indicate the size of the research task. There are many other current and emerging problems of sparsely settled areas that need to be identified and investigated.

No general theory of local government is available to serve as a basis for a study of governmental needs in sparsely populated areas.[22] Never-

[22] A notable step to create such a theory has been taken in Arthur Maass, ed., *Area and Power: A Theory of Local Government*, Glencoe, Ill., The Free Press,

theless, some suggestions can be advanced to guide proposals to fit local government activities more closely into present-day economic and social patterns of these areas. Three important factors that should receive serious attention are that local governments should be: (1) general in nature, (2) flexible, and (3) politically responsible. The local government unit should have the general power to do all local government tasks that are to be done within its boundaries. It should be flexible so that its organization and activities can be expanded or contracted by the local citizens as conditions change. In a democracy, government must be responsible to the people. This responsibility seems to be most readily attained when governmental power rests visibly in the hands of a few elected officials. It is essential that the responsibility be limited to a very few officials, so that the responsible official can be identified by the citizens.

A great deal more research is needed to enable local citizens to understand clearly the nature of the problems facing their local communities, and the alternative courses of action that might help to solve the problems. Major social and economic changes have occurred in rural areas, and further changes can be expected. Those who are interested in local self-government must see to it that local government organization is adequate to provide the services that are required now and in the future.

1959. The interested reader is referred especially to the first two chapters, by Arthur Maass and Paul Ylvisaker, respectively.

THE HOG CYCLE AND THE COBWEB THEOREM

ARTHUR A. HARLOW
Agricultural Marketing Service

A surprisingly regular four year cycle in hogs has become apparent in the past ten years. This regularity presents an unusual opportunity to study the mechanism of the cycle because it suggests the cycle may be inherent within the industry rather than the result of lagged responses to outside influences. The cobweb theorem is often mentioned as a theoretical tool for explaining the hog cycle, although a two year cycle is usually predicted. When the nature of the hog industry is examined, certain factors become apparent which enable the cobweb theorem to serve as a theoretical basis for the present four year cycle.

THERE has been increasing awareness of a fairly regular four year cycle for hogs in recent years, although the existence of a hog cycle has been recognized for over three-quarters of a century.[1] The hog cycle may be described in terms of price or production. Production may be measured at the initial or final stage, i.e., pig crop or slaughter. This article examines the interrelationships among these three manifestations of the hog cycle—price, pig crop and slaughter—and attempts to determine the suitability of the cobweb theorem as a theoretical framework for an explanation of the cycle.

The use of annual data in charting hog cycles may tend to obscure some responses of farmers to changing conditions because there are usually two farrowings per year. The typical practice is to breed sows in the fall to farrow in the spring about four months later. A large proportion of these sows farrow again the following fall. Most analysts have found that farmers make their basic decision as to the number of sows to farrow on a yearly basis, with some adjustment of fall farrowings in response to changed conditions.[2] For this reason annual figures are used in this presentation, although there is the possibility of a slight loss in precision due to over-aggregation.

A Model of the Hog Cycle

In order to show clearly the interrelationships of the different aspects of the hog cycle, factors which affect hog production but are not mate-

[1] See Breimyer, Harold F., "Emerging Phenomenon: A Cycle in Hogs," *J. Farm Econ.* 41:760-68, Nov. 1959.

[2] For example see Brandow, G. E., *Factors Associated with Numbers of Sows Farrowing in the Spring and Fall Seasons,* Pa. Agr. Expt. Sta. A. E. and R. S. 7, 1956; Dean, G. W., and Heady, E. O., "Changes in Supply Response and Elasticity for Hogs," *J. Farm Econ.,* 40:845-60, Nov. 1958; Kohls, R. L., and Paarlberg, Don, *The Short Time Response of Agricultural Production to Price and Other Factors,* Purdue Univ. Agr. Expt. Sta. Bul. 555, Oct. 1950.

rially affected by it, i.e., independent or exogenous variables such as the price of corn and the feed supply, are assumed to be constant. This assumption of *ceteris paribus* is, of course, a distortion of reality, but it is necessary for a clear, simple explanation of the basic relationships.[3]

The three measures of the hog cycle are related in the following manner. Price in one period affects the size of the pig crop the following period, which in turn determines the number slaughtered. The number slaughtered affects the price, which influences the next pig crop and so on around a circular chain of reaction. The cyclical nature of the relationships is obvious. The lag between price and pig crop and between pig crop and slaughter determines the length of the cycle.

A four year cycle, such as the one now observed for hogs, will result if each of the above lags is assumed to be one year. A model using these assumed lags will be developed, and then the validity of the assumptions will be examined.

Diagrams A, B, and C in figure 1 illustrate the assumed relationships of each of the three variables with each other. The relationships are shown in cyclical form, although the reason for the cyclicality is not evident until all three are examined simultaneously in diagram D. The one year lag between price and pig crop is shown in figure 1A. A high price in one year leads to a large pig crop the next year and a low price is followed by a small crop. Pig crop precedes slaughter by a year as indicated in figure 1B. The size of the pig crop determines the number slaughtered in the following year. The inverse relationship between slaughter and price is illustrated in figure 1C; when slaughter is high, price is low and vice versa. With these relationships between each of the variables clearly in mind, it will be easier to understand the formation of the cycle which arises from their interaction.

The reason for the development of a cycle from the interrelationships is revealed by an examination of figure 1D, which combines the three series. Assuming the initial positions as shown for year 1, the cycle would proceed as follows. Initially slaughter is low, price is high and the pig crop is of normal size. The next year slaughter will increase to the normal or average level, reflecting the size of the previous year's pig crop, and price will correspondingly decrease to normal. But now (year 2) the pig crop is larger than normal due to the high price the previous year. Consequently, slaughter increases and price declines below average during year 3. Farmers breed fewer sows in year 2 because of the lower price and hence the pig crop drops to the average level again the next year.

[3] In an examination of livestock cycles, Lorie stresses "the interrelationships among value, marketings, and numbers on farms (or production)." See Lorie, James H., *Causes of Annual Fluctuations in the Production of Livestock and Livestock Products* (Chicago: Univ. of Chicago Press, 1947).

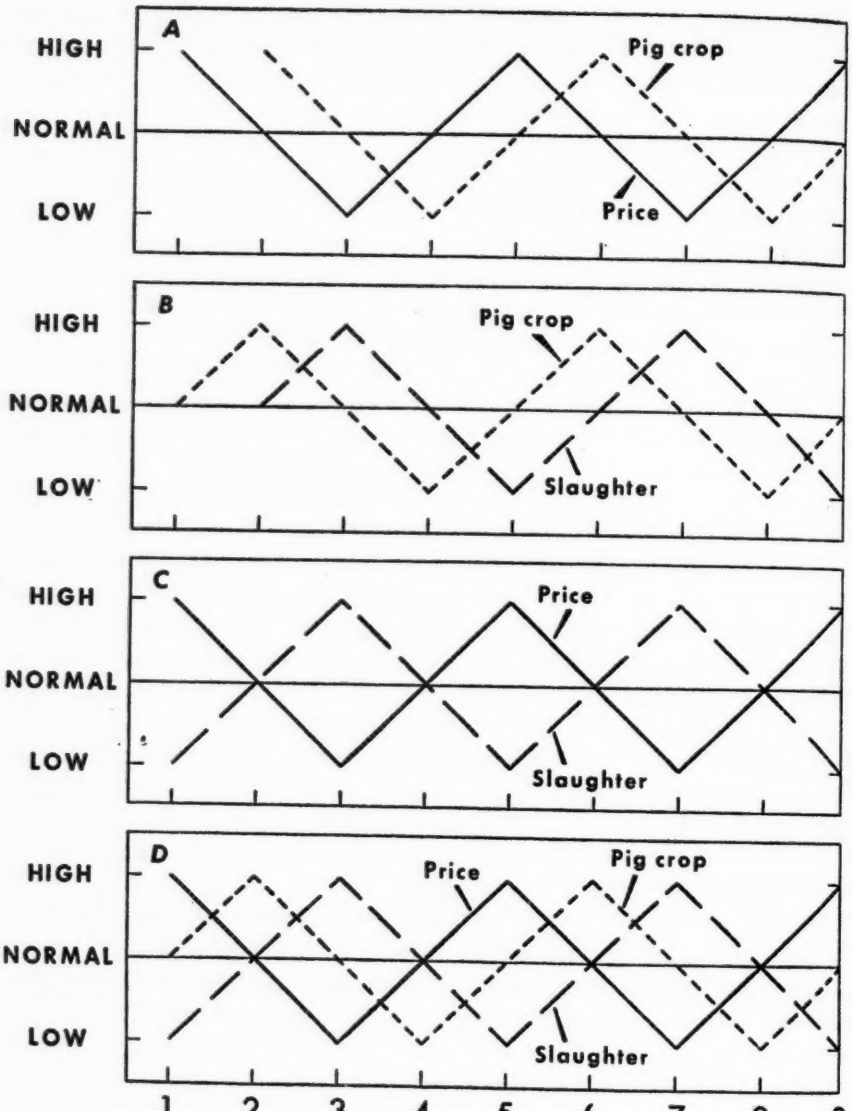

FIG. 1. HYPOTHETICAL RELATIONSHIPS BETWEEN MEASURES OF THE HOG CYCLE

The normal sized pig crop in year 3 leads to lower slaughter and higher prices which again reach the average level in year 4. However, the low price in year 3 results in a further cut in production in year 4 and so the pig crop is now at a low point. The next year slaughter declines due to

the small pig crop the previous year and consequently price rises to a peak in year 5. The relatively higher price in year 4 leads farmers to increase production to the normal level in year 5 which results in the same relationships among the variables as occurred four years previously, and the cycle continues as before.

Different initial positions could result in different shapes for the curves. For example, the peaks would be less pointed if pig crop and slaughter were both assumed to be at normal levels initially, and a shift in demand caused a change in price. The cycle would still be four years in length, however, as long as the lags were each one year.

Comparison with Actual Data

A comparison of this simple model with the actual data will assist in determining whether the assumptions made in its formulation are appropriate. An exact likeness would not be expected because there are many exogenous variables which affect the hog industry and distort the smooth theoretical relationships. The price of hogs depends upon demand as well as supply and the demand for pork is affected by consumer income and the prices and supplies of competing meats.

On the supply side, there are many factors besides price which have an effect on the size of the pig crop. The price and supply of feed and the relative profitability of alternative uses of farmers' labor and feed are important factors in determining the number of sows farrowing. The number of pigs saved is influenced by weather, genetics and production practices in addition to the number of sows farrowing. The number slaughtered differs from the size of the pig crop because of the number of gilts saved for breeding purposes and the number of deaths that occur between the counting of the pig crop and slaughter.[4] Also, the supply of pork is determined by the average slaughter weight as well as the number slaughtered.

In order to obtain a four year cycle in the model, it was necessary to assume one year lags between price and pig crop and between pig crop and slaughter. These lags are somewhat longer than those expected from the physiological processes involved in hog production. The gestation period is slightly less than four months, pigs are weaned in about two months, and an additional four to six months are usually required for feeding to market weights. Using these approximate six month lags between breeding and weaning and between weaning and slaughter, the resultant cycle would be two years instead of four years in length.

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[4] Ideally the pig crop should be the number of pigs weaned, but the "pigs saved" series compiled by the USDA consists of the number of spring or fall pigs on hand June 1 or December 1 or sold before those dates.

There are two main reasons for the existence of yearly lags. The first is the previously cited evidence that, at least in the past, farmers have tended to plan hog production on an annual basis. Whether this practice will continue with the changing technology of hog production is open to question. In the last two years the size of the fall pig crop has not varied with the spring crop as closely as it usually has in the past decade.

The second reason is the statistical limitation imposed by the use of annual data. Their use requires that measurements be made in terms of

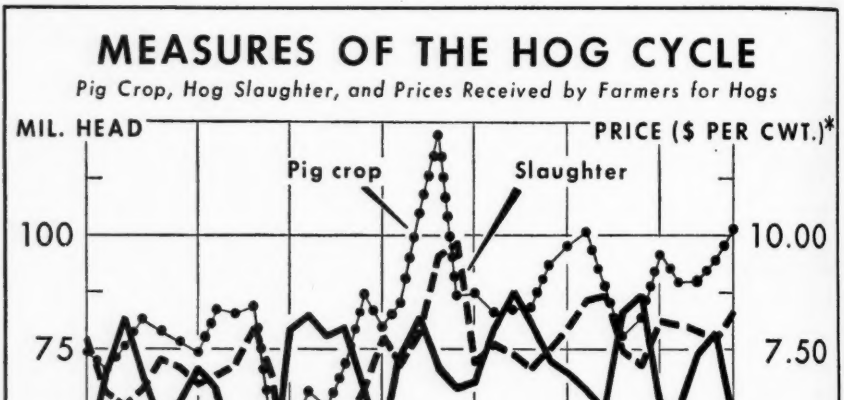

FIG. 2

years although the actual figures may vary considerably from a precise twelve months. The use of a calendar year instead of a marketing year also introduces a predilection toward annual lags. The price of hogs when sows are bred in the fall affects the number of sows farrowing the following spring and the following fall. The actual lag between the price which influences farmers to breed more sows and the increased pig crop resulting from this decision may be as short as six months for the spring crop. However, the price occurs in one calendar year and the pig crop in the next so the lag between them becomes one year with this imprecise measurement. The actual lag between pig crop and slaughter is also con-

siderably less than a year. But since all the fall crop and part of the spring crop are slaughtered the following year, annual slaughter figures tend to lag the annual pig crop by a year.

When the actual data are graphed, their interrelationships are surprisingly close to the theoretical model, especially since 1950. (See figure 2). There have been two complete four year cycles in the past eight years, and the relationships among the variables were as predicted by the model. Price preceded pig crop by one year and slaughter followed the pig crop by a year. Prices were high when slaughter was low and vice versa. All three series rose two years, fell two years, then rose again two years and fell two years, as would be expected from the theoretical model.

Prior to 1950 the cycle was not as evident, although the interrelationships were similar. Pig crop led slaughter by a year except during the 1930's when drought and depression obscured the relationship, and the inverse price-slaughter relation held except during some of the war years when price controls were in effect. Hog production was influenced much more by the supply of corn in the prewar than in the postwar period because smaller stocks were carried over from year to year. The price support program and favorable weather in the postwar years have contributed to the development of relatively stable corn prices and the accumulation of large stocks of feed grains. In the prewar period, however, fluctuations in the corn supply due primarily to the weather tended to create random disturbances in the cycle and prevented its regular appearance.[5]

Other discrepancies between the model and the actual figures arise because of the limitations of the statistical data which in many cases are estimates based on sample surveys. But in view of the simplifying assumptions which were made in the formulation of the model, the actual data fit the basic pattern surprisingly well.

Applicability of the Cobweb Theorem

The cobweb theorem has been discussed at various times as an explanation for the hog cycle, both in England and the United States.[6] The relationship between price and supply hypothesized by the cobweb theorem can arise only if the time lag between a change in price and the resulting supply response is sufficient to create a relatively fixed supply for a given period. According to the theorem, a large supply and low

[5] For an elaboration of these points see Breimyer, Harold F., *op. cit.*

[6] See Coase, R. H., and Fowler, R. F. "Bacon Production and the Pig-Cycle in Great Britain," *Economica,* 2:142-67 May 1935; also reply by Ruth Cohen and J. D. Barker, and rejoinder by Coase and Fowler, *ibid,* 2:408-28, Nov. 1935; Coase, R. H., and Fowler, R. F., "The Pig Cycle in Great Britain: An Explanation," *ibid,* 4:55-82, Feb. 1937; Dean, G. W., and Heady, E. O., *op. cit.*

price in one period will be followed by a small supply with an accompanying high price in the next period, which in turn will be followed in the succeeding period by a large supply and a low price, and so on. Assuming there are no external influences, these fluctuations will either increase or decrease in amplitude, or continue at the same level indefinitely depending upon the slopes of the demand and supply curves.

The application of the theorem depends upon the fulfillment of three conditions. (1) Producers plan for output in the next period on the basis of present prices. (2) Once production plans are made, they are unalterable until the following time period. (3) Price is determined by the available supply, i.e., price is set by the intersection of the demand curve with a vertical supply curve.

The production of hogs probably approximates these conditions as well as any agricultural commodity. Available evidence indicates that the extension of current prices is of major importance in future production plans. Production is essentially fixed once sows are bred, at least on the upward side. Farmers can decrease production by marketing bred sows although there is a considerable discount after the second month of pregnancy. There is some variation in marketing weights in response to price and other factors, but supply is relatively fixed in any given year.[7]

The discussion of the suitability of the cobweb theorem as a theoretical basis for the hog cycle has centered around the length of the cycle predicted by the theorem compared with the length of the observed cycle. Opponents of the theorem maintain that "if farmers acted according to the assumptions of the 'Cobweb Theorem,' the technical conditions are such that a cycle of about two years would arise. Since it is generally agreed that the cycle is much longer than this, it is clear that this furnishes additional grounds for rejecting the theorem."[8]

And proponents of the theorem argue that a two-year cycle would appear except that "the pattern is disrupted by shifts in the demand and supply functions due to World War II, the Korean War and other important factors. Feed grain supplies and the prices of competing farm products probably also play a role not accounted for by this simple model."[9]

A Four Year Cycle from the Cobweb Theorem

The length of the cycle produced by the cobweb theorem depends upon the time required for a change in price to affect supply. The ex-

[7] Dean, G. W., and Heady, E. O., *op. cit.*, p. 846.
[8] Coase, R. H., and Fowler, R. F. "The Pig-Cycle in Great Britain: An Explanation," *op. cit.*, p. 77.
[9] Dean, G. W., and Heady, E. O., *op. cit.*, p. 848.

pectation of a two year cycle in hogs may be due to the use of the technical lag in hog production while ignoring some of the other lags involved. The time required to produce an average pig, from breeding to slaughter, is approximately twelve months. Using this lag, the cobweb produces a two year cycle. The lag involved in the cobweb theorem, however, is the lag between price and its effect on market supply which is not necessarily the lag between breeding and slaughter.

The lag between price and marketings has been longer than the one year between breeding and slaughter because of the lag between price and farmers' response to it. This latter lag is not determinate *a priori* because it depends largely upon producers' expectations. If farmers expect a price to continue in the future they will respond to it, but if the price is thought to be only temporarly, it will initiate little or no response. There is also a period of variable intensity of the effect of price. In other words, price during one year may have some effect on production decisions during the next two or three years in addition to its more pronounced effect in the immediately succeeding year.

The imperfections of annual data with respect to hog production have been discussed previously. When annual data are used, there has been an approximate two year lag between price and its effect on marketings in recent years. Using this lag, the three conditions of the cobweb theorem are not approximated as closely, but the actual hog production process is perhaps better described.

The recent experience of a two year lag gives empirical evidence about the speed with which hog producers react to changes in price. The fastest possible reaction from price to marketing is the one year required to produce a pig. Thus the two year lag indicates that there is some lag between price and production response in addition to the lag between breeding and slaughter.

With a two year lag in supply, Ezekiel's extension of the cobweb theorem produces a four year cycle.[10] The simplest case of the cobweb theorem is that of continuous fluctuations. This occurs when, assuming linear functions, the demand curve has the same absolute slope as the supply curve. Figure 3 illustrates what happens in this case with a two year lag in supply, i.e., marketings.

Since it takes two years for the supply response to be completed, it is necessary to assume prices or quantities marketed for the first two years. The position of these assumed quantities will determine the shape of the cycle resulting from the cobweb within the limitations imposed by the supply and demand curves. The quantities Q_{t1} and Q_{t2} are posi-

[10] Ezekiel, Mordecai. "The Cobweb Theorem," *Quar. J. Econ.* 52:255-80, Feb. 1938.

tioned so that the resultant cycle will roughly approximate the shape of the hog cycle observed during the past eight years. These quantities result in prices P_{t1} and P_{t2}. The response to the low price P_{t1} is reflected in marketings two years later by the quantity Q_{t3}. This small quantity results in a high price P_{t3} which in turn is followed two years later by the large marketings Q_{t5} and the process continues in alternate years around the same pathway. The price in the second year, P_{t2}, is followed in a

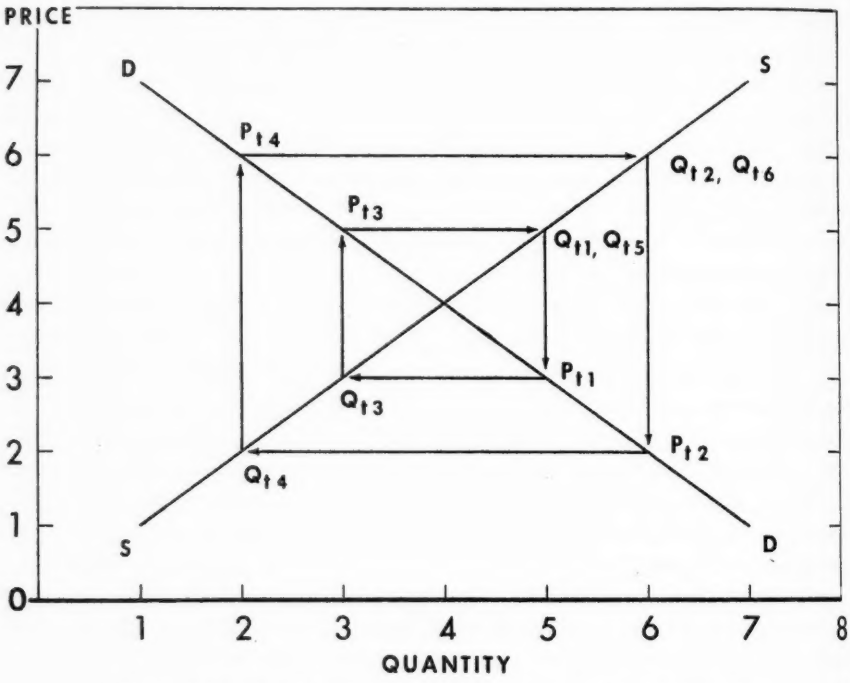

FIG. 3. THE COBWEB THEOREM WITH A TWO YEAR LAG IN RESPONSE

similar manner two years later by the quantity Q_{t4} and by price P_{t4} which is followed in another two years by quantity Q_{t6} and so on.

Theoretically there are two separate pathways for odd and even years. In reality, however, conditions in the hog industry in one year affect conditions in the next. But at least in the recent past, the major impact has been delayed until two years later so that this separation has been maintained to some degree. If the two pathways were completely independent of each other, there would be an infinite number of possibilities in the cyclical pattern depending upon the location of Q_{t1} and Q_{t2}.

Since the Korean War there have been no major changes in outside factors affecting the hog industry. So, assuming that conditions have been

favorable for the operation of the cobweb theorem since 1953, the high slaughter figures for 1951 and 1952 would determine the position of Q_{t1} and Q_{t2}, and the pattern of two high years followed by two low years would be established.[11]

When the prices and quantities given in figure 3 are placed on a time series chart, the cyclical nature of the process is clearly evident. The 4-year cycle produced by this cobweb relationship is shown in figure 4.

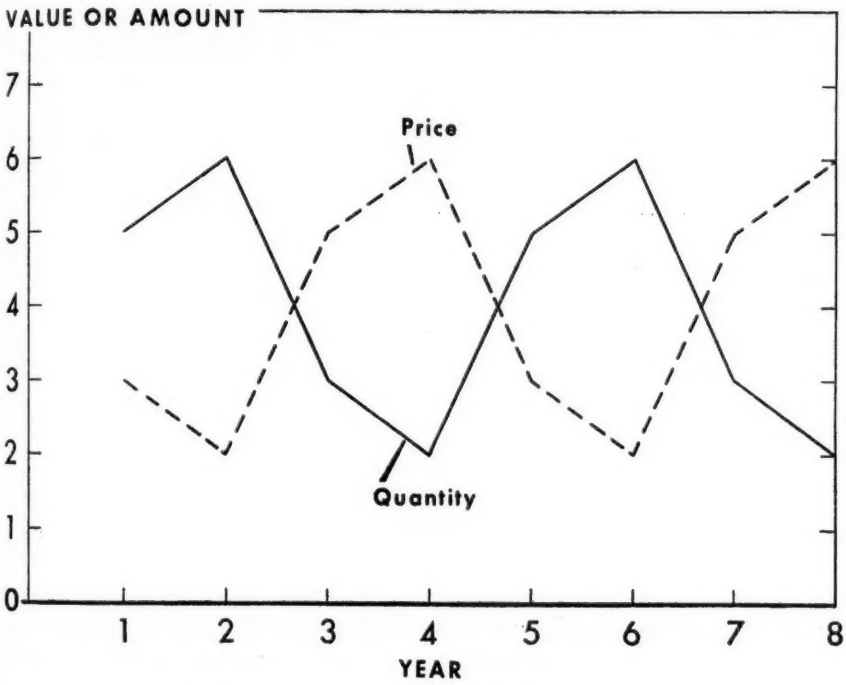

FIG. 4. OBSERVATIONS FROM FIGURE 3 PLOTTED AS A TIME SERIES

This cycle is similar to the one developed earlier by the examination of the interrelationships among price, pig crop and slaughter. The only difference is that for ease of explanation, the price and quantity series in figure 1 were assumed to be in equilibrium in alternate years while no such assumption is made in figure 4. A cobweb relationship with a 2-year lag and the second year, e.g., Q_{t2} in figure 3, located at the intersection of the supply and demand curves would result in a time series graph identical with figure 1C.

[11] The two years prior to 1953 are used as initial points because since then outside influences are assumed to have been stable, and theoretically a period of instability is needed to create a movement away from an equilibrium position.

Various types of cycles can be produced by the cobweb theorem by using different supply and demand curves, initial positions and lags. Supply and demand curves plus the initial positions determine the shape and amplitude of a cycle while the lag between price and marketings determines the cycle length. The cobweb theorem thus has sufficient flexibility to serve as a theoretical basis for a variety of cycles. The Akerman variant on the cobweb principle further increases its flexibility by introducing a series of different, successively arising and vanishing short term supply curves which may be closer to reality than a single long term supply curve.[12]

Summary

A four year cycle in hogs has appeared in the last decade and has continued with surprising regularity. The interrelationships among price, pig crop and slaughter could account for a cycle of this length if there were initial disequilibrium and no outside interference. However, outside influences are ever present and their effect is constantly changing although they do not usually occur in regular cyclical patterns. This statement is especially true for the hog industry where the major exogenous factors are the price and supply of feed which in turn are affected by the weather. In recent years, favorable weather and the price support program have produced abundant feed supplies with relatively stable prices. The appearance of the present regular cycle in hogs while outside influences are comparatively stable would seem to indicate an inherent cyclical character within the industry.

The length of time required for reproduction and growth results in an inevitable lag in the response of agricultural commodities to changes in the factors which influence their production. The cobweb theorem is a theoretical tool which has been used as an explanation for cycles resulting from such lags in response. Using appropriate lags, the application of this theorem results in a four year cycle for hogs instead of the two year cycle its application usually produces. The cycle thus produced is similar to the one which was found to arise because of the interrelationships among price, pig crop and slaughter. The similarity of the cycles produced by the two methods occurs because the interrelationships are determined by the nature of the hog industry which also determines the lag required for the application of the cobweb theorem. The cobweb theorem furnishes a more precise theoretical explanation of the cycle because it includes the demand and supply functions for the industry,

[12] See Akerman, Gustave, "The Cobweb Theorem: A Reconsideration," *Quar. J. Econ.*, 71:151-60, Feb. 1957.

which determine the amplitude of the cycle, as well as the lag in production response, which determines the cycle length.

Whether the cycle continues its present regularity depends upon the effects of outside influences and the extent to which producers' responses change. As producers become better informed about probable future hog prices, they will adjust production more according to outlook information. Increased reaction to anticipated prices rather than past prices will tend to dampen and shorten the cycle.

Many factors which could affect the cycle, such as the varying numbers of breeding stock withheld from present marketings and the variation in weight and age of hogs marketed, are ignored or assumed constant in this analysis. Also, the use of annual data forces the observed cycle into a whole number of years while the actual responses may not be of precisely twelve months' duration. These areas merit further, more detailed investigation.

UNIFORM GRADES AND STANDARDS, PRODUCT DIFFERENTIATION AND PRODUCT DEVELOPMENT

PAUL L. FARRIS*
Purdue University

UNIFORM grades and standards have received considerable support for their contribution to the operation of our agricultural marketing system. They facilitate trade and generally improve the allocative efficiency of the pricing process. Product differentiation, on the other hand, has been considered an imperfection which interferes with pricing efficiency and effective resource allocation. However, product differentiation may be used advantageously by individual firms, and differentiation may increase product variety.

This paper suggests that the theoretical bases for both uniform grades and standards and product differentiation are stronger than we have traditionally believed when we consider dynamic interrelations between the two. In looking upon marketing as a moving and evolving process,[1] the interrelations may be complementary from the standpoint of product improvement and development.

The Economics of Uniform Grades and Standards

Uniform grades and standards exert their influence through increasing knowledge about the product.[2] More knowledge increases price competition. When markets become more perfectly competitive, consumer demands tend to be reflected more accurately back to producers. Rewards to producers are more in accordance with consumer evaluation of quality attributes contained in products marketed.[3]

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[1] The dynamic aspects of marketing in a changing and developing economy are emphasized in this paper. "Survival and growth are implicit goals of every behavior system, including most particularly those which operate in the market place." There is among firms "competition for differential advantage." See Wroe Alderson, *Marketing Behavior and Executive Action* (Homewood, Ill.: Richard D. Irwin, Inc., 1957), p. 1 and Chapter IV, pp. 101-29.

[2] Thomsen's definitions of grading and standardization appear to be generally accepted and are used in this paper. "*Grading* is the sorting of products into lots, each of which has substantially homogeneous quality characteristics." "*Standardization* means making uniform among buyers and sellers, and from place to place and time to time, the quality specifications of grades."—Frederick Lundy Thomsen, *Agricultural Marketing* (New York: McGraw-Hill Book Co., Inc., 1951), pp. 262 and 267.

[3] "The principal objective of an ideal standard should be *to aid the consumer in telling the producer what he considers desirable in a product for the particular use to be made of it.*"—Richard L. Kohls, *Marketing of Agricultural Products* (New York: The Macmillan Co., 1955), p. 139.

Included in making markets more perfectly competitive is what Duddy and Revzan call the "ethical basis for marketing transactions. . . . As long as no objective standard prevails there is opportunity for the strong to take advantage of the weak, for the clever and unscrupulous to outwit the unwary and trusting."[4]

Uniform grades and standards, or specifications, also facilitate trading through making it possible to deal in quantities of a commodity more easily and efficiently. Advantages include more meaningful price quotations, the ability to trade on the basis of sample or description, and the pooling or mingling of products. Uniform grades and standards thereby facilitate the performance of such marketing functions as financing, transportation and storage.[5]

Of course, a useful standard must rest on important and recognizable characteristics which can be accurately and uniformly measured and interpreted. Furthermore, standards should depend on familiar factors, be phrased in familiar terminology, and they should be realistically applicable to product characteristics.[6] The practical problems of specifying and applying uniform grades and standards for some products are considerable.[7] Overcoming these problems may at times complicate the attainment of efficiencies theoretically possible with uniform grades and standards. Time is needed to identify, standardize and perfect measurements for most product quality characteristics. More time may elapse before consumers or users of the products accept the standards and learn to use them in making buying decisions.

The Economics of Product Differentiation

Product differentiation includes any significant basis "for distinguishing the goods (or services) of one seller from those of another. Such a basis may be real or fancied, so long as it is of any importance whatever to buyers, and leads to a preference for one variety of the product over another."[8] Product differentiation is facilitated by imperfect product knowledge, and, in some cases, may move in opposition to the application of uniform grades and standards.

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[4] Edward A. Duddy and David A. Revzan, *Marketing* (New York: McGraw-Hill Book Co., Inc., 1947), p. 59.

[5] Adapted from Kohls, *op. cit.*, pp. 141-42.

[6] *Ibid*, pp. 143-44.

[7] See, for example, excerpts and references in Frederick V. Waugh (Ed.), *Readings on Agricultural Marketing* (Ames: The Iowa State College Press, 1953), pp. 298-313, and Gerald Engelman, "An Economist Looks at Meat Grading and Consumer Studies," A Statement to the Conference on Consumer Studies and Meat Quality, University of Missouri, Columbia, Sept. 9, 1957.

[8] Edward H. Chamberlin, *The Theory of Monopolistic Competition* (Cambridge: Harvard Univ. Press, 1946), p. 56.

Product differentiation or product variability, according to Abbott, may take three forms: vertical, horizontal and innovational.[9] Vertical differences concern the higher and lower qualities of a good. A higher quality good has attributes which are held to be superior by virtually all buyers, and the cost of supplying the product is greater. Horizontal differences are those about which there is no clear agreement—different people would rank dissimilar qualities in different orders, and cost differences, if any, are only incidental. Innovational changes are considered improvements by most or all buyers, but either cost no more or are judged superior in spite of whatever additional cost is involved, so that the new quality displaces the old.

Product differentiation implies and facilitates nonprice competition. Nonprice competition is essentially of two kinds: (1) product competition and (2) promotional competition.[10] Product competition concentrates on the quality of the article itself, and consists of both the *physical aspects* of the commodity and the *differences in services* associated with the sale. Product competition is used in an attempt to adapt the good more sensitively to the tastes and preferences of consumers.

Promotional competition is undertaken to modify the buyer's scale of preferences. Wherever quality variation is possible, promotional activity has some basis for attempting to instill in the consumer the belief that the given brand possesses desirable qualities distinct from and superior to those of other brands in the chain of related articles. "Quality variation addresses itself to the product; it manipulates the product. Sales promotion addresses itself to the customer; it manipulates the customer."[11]

Thus, product differentiation can help a firm secure and keep a market for its products. In addition, product differentiation can add to consumer satisfaction by increasing the range of consumer choice.

But nonprice competition is not without social costs. "It can be argued that some or much of the so-called quality variation indulged in by many firms and some or much of the resulting multiplicity of brands are of spurious, fictitious character; that often product variation exemplifies a distinction without a difference. Moreover, the consumer is confronted with diverse claims, varieties, sizes, and prices for a given product, and he cannot easily reduce these elements to a comparable basis for an intelligent choice. . . . The result is a maldistribution of resources toward making goods which the consumer would decline to buy at ruling prices

[9] Lawrence Abbott, *Quality and Competition* (New York: Columbia Univ. Press, 1955), p. 129.

[10] M. M. Bober, *Intermediate Price and Income Theory* (New York: W. W. Norton & Co., Inc., 1955), pp. 249-53.

[11] *Ibid*, p. 237.

if he were more adequately informed. This serious defect may be remedied in proportion as the consumer is better educated about his purchases and as there is greater insistence on less extravagance and more truth in advertising."[12]

Product differentiation, furthermore, may be associated with a market structure in which firms are operating at less than optimum capacity and charging a higher than competitive price.[13] Stewart and Dewhurst concluded that distribution did cost too much essentially because of inherent tendencies under the existing competitive structures toward duplication of facilities and toward leaving consumers poorly informed about the multiplicity of products, brands, advertising and selling effort. Their research findings indicated that newer distribution agencies, through economies of standardized and large-scale operation, had proven the inefficiency of those they displaced, and that other distributors were able to lower costs and survive.[14]

The duplications of plant and selling effort which tend to accompany structures of monopolistic competition take a number of forms in our modern distribution system. This duplicative effort, along with imperfect consumer knowledge and the consequent consumer disutility associated with making buying decisions in markets of many differentiated products, must be weighed against the added social gains which may come from greater product variety.

Complementary Relationships Between Uniform Grades and Standards and Product Differentiation

When we consider marketing activities as dynamic processes, there appear further useful roles for both uniform grades and standards and product differentiation. The application of uniform grades and standards, by increasing product knowledge, tends to eliminate sources of differentiation. Some previously unknown or poorly known product attributes tend to pass from differentiating factors to specifications of standard acceptance. New or less known product attributes must then be sought for successful differentiation. More knowledge about existing products can help stimulate enterprisers to seek out new product attributes, to develop new qualities or even to develop new products, in the search for profitable differentiation.

This is the dynamic process with which we are concerned. "The introduction of a new good—that is one with which consumers are not yet

[12] *Ibid*, p. 252.
[13] *Ibid*, p. 243.
[14] Paul W. Stewart and J. Frederic Dewhurst, *Does Distribution Cost Too Much?* (New York: The Twentieth Century Fund, 1939), p. 348.

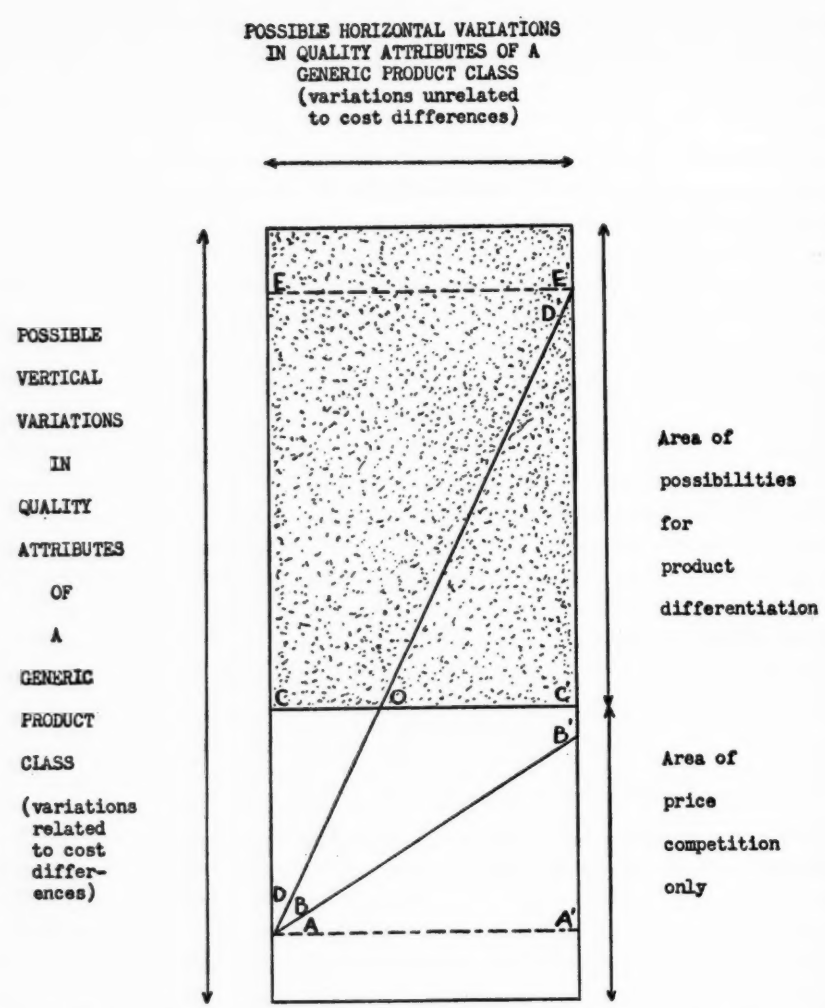

FIG. 1. DIAGRAMMATIC ILLUSTRATION OF THE RELATION BETWEEN UNIFORM GRADES AND STANDARDS AND PRODUCT DIFFERENTIATION IN PRODUCT DEVELOPMENT.

familiar—or of a new quality of a good," is one of the five cases which Schumpeter identified as sources of economic development.[15] Product differentiation, then, may be a form of innovation.

Profit incentives are needed to stimulate such innovation. But, paradoxically, for the innovating process to continue, the advantages of any particular innovation should not be perpetuated indefinitely. Thus uni-

[15] Joseph A. Schumpeter, *The Theory of Economic Development* (Cambridge: Harvard Univ. Press, 1934), p. 66.

form grades and standards and product differentiation can complement each other in the process of product improvement and development.

An Illustration of Product Development

The process is illustrated more fully in Figure 1. Vertical and horizontal dimensions in the figure indicate the possible ranges of vertical and horizontal quality attributes which products in a generic product class may possess. Actual products may have various combinations of vertical and horizontal quality attributes within these ranges. Any combination of vertical and horizontal product change may occur within these ranges.

When an innovational change occurs, a new generic product class comes into existence. A new set of vertical and horizontal dimensions then apply to quality attributes of the new product class. New dimensions define the area of possible vertical and horizontal changes for products in the new class until another innovational change occurs. Then another set of dimensions apply.

Each of the lines in the diagram would probably need to be drawn differently for different commodities, and for a commodity at different stages in its movement from producer to consumer. It is possible, however, to categorize products and commodities according to their position on Figure 1. At primary production and processor levels there is little opportunity for product differentiation. The more a product changes or other attributes or services are added to the product enroute through the processing and distribution channel, the more numerous tend to be the opportunities for product differentiation, and the more remote tends to be the relationship to product quality attributes at primary production levels.

For a given generic product class, then, line AA′ indicates the lowest acceptable limit of product quality attributes. Products with all attributes below this line are not suitable for any commercial use.

The diagonal line BB′ indicates the minimum acceptable standards for health and safety. There are varying degrees of minimum quality because of variability in product requirements for different uses. Moving from left to right, products are arranged in the order of increasing quality requirements for different uses, resulting in the upward slope of line BB′. The slope of this line, of course, varies for different product classes. It may be curvilinear, possess stair step characteristics or perhaps have no slope at all.

Line CC′ is horizontal and indicates the current standardization limit of quality attributes for the product class. In the case illustrated in Figure 1, line CC′ is above the highest point on line BB′. The level of

standardization has gone far enough to make products of this class available, from the standpoint of health and safety, for all product uses.

In the area below line CC′, product attributes have become accepted standards or uniform specifications. Here, there is price competition only. Actual products contain various combinations of vertical and horizontal quality attributes, but knowledge is sufficiently adequate that there is no further opportunity for using attributes below line CC′ as differentiating factors. There may be imperfections in any actual market so that prices for attributes below line CC′ would differ from prices which would be expected under perfectly competitive conditions. But such price differences would not be traceable to product differentiation.

Above line CC′ knowledge of product quality attributes is vague. There are as yet no technically feasible ways of accurately identifying and quantifying attributes in this area. Individual firms may discover attributes above line CC′ to use as differentiating factors, and they may be able to quantify these to their own advantage before such knowledge becomes general. Thus, possibilities for profitable product differentiation lie in this area.

There is upward pressure on line CC′ in a dynamic economy. Technological advances in standardization and grading techniques, and in product production, marketing and distribution, destroy some advantages of product differentiation. Improvements in market information, communications and transportation, the breakdown of local or regional trade barriers, and the growth of national markets all play a part. These forces tend to increase competition among firms and to cause technological advances to be put into use. As the process goes on, (1) the average quality level of actual products made available tends to rise, (2) more of the vaguely defined product quality attributes become standardized and measurable, and (3) new differentiating factors are sought.

There are upper limits to the raising of product quality and to the specification of product quality attributes. Line DD′ indicates the practical limits of standardization. There is downward resistance at various points along line DD′ because buyers can not be expected to pay for more costly quality attributes than are desired in products for their particular purposes.

Moving from left to right on line DD′, products are arranged in the order of increasing quality demands for different product uses. For some product classes there may be wide ranges of quality attributes demanded, thus giving the line for such a class a rather steep upward slope. As was true for line BB′, the location and configuration of line DD′ vary a great deal among product classes. Nevertheless, line DD′ is above line BB′ because there are demands for quality attributes above minimum require-

ments for health and safety. Line EE′ indicates the upper limit above which further quality improvement and specification would not be feasible—the cost would be greater than would be paid by any users of products from the class.

As the process of product improvement and quality attribute identification and specification proceeds, the remaining opportunities for profitable exploitation of vaguely known attributes as differentiation factors diminish. The opportunities are bounded by the triangle OC′D′.

With the passing of time, upward forces on line CC′ and downward resistance on line DD′ reduce the size of the triangle. The right side of the triangle line C′D′, is arbitrarily defined to bound the limit of possible horizontal variations in quality attributes. The slope or shape of line DD′ may undergo change, because of demand shifts, for example, while line CC′ moves up. But it is very unlikely that such changes eventually would keep triangle OC′D′ from becoming smaller.

As the triangle becomes smaller, entrepreneural activity proceeds more vigorously in two directions: (1) More powerful selling techniques tend to be employed to try to create the impression of product differences,[16] and (2) Pressures for product innovation become more intense. Product innovation might be considered a third upward movement from the triangle OC′D′ to a new set of dimensions for a new product class.

While there may not always be promising opportunities for new product development, there is at least this possibility. Many firms consider favorably the potentialities of product innovation. Research departments more and more are centering attention on new product development as a form of "competition for differential advantage." New product development need not approach any limit in a changing, developing economy. This kind of product change may come, of course, before profit opportunities from a given product are fully exploited .

Implications for Public Policy

There are at least three ways in which government or outside assistance appear desirable with respect to product change and development.

First, there is need to safeguard certain minimum standards for health and safety in various product uses. Because of two developments associated with our advancing economy, this need is becoming more urgent at consumer levels, particularly for food. Rising real consumer income is increasing ability to satisfy wants, thus providing a greater potential for

[16] A major dilemma "forcing marketers to search for more powerful tools of persuasion was the growing sameness of their products, with increased standardization."—Vance Packard, *The Hidden Persuaders* (New York: Pocket Books, Inc., 1957), p. 16.

product differentiation and new product development. Consumers are also buying more food in highly finished form, which means they are purchasing in the market many quality attributes that formerly were added in the kitchen. These trends seem likely to continue. Consequently, there is increasing need for product knowledge, even about such elementary standards as weight, volume, content and purity, in order that consumers can choose wisely among the rapidly expanding number of products.

Second, since there is a continuing stream of new products, it may be advantageous for public agencies to participate actively in the development of new standards and in methods of applying the standards. Government can provide leadership through research, education and service, particularly where quality attributes are many and varied and where the identification and rapid determination of important attributes are difficult. Where current grades and standards about existing products appear realistic and useful, public agencies can increase information about the meaning, use and interpretation of the grades and standards in order to increase product knowledge.

Some enterprises are understandably opposed to an extension, or more effective application, of uniform grades and standards.[17] A shift in the competitive environment would often be forthcoming. Firms whose market positions are sustained primarily on the basis of product differentiation would tend to lose because of more severe price competition from other firms who would supply products with certain quality specifications at lower prices.

There probably is need for some assurance that profits from product development will not immediately be eroded by the application of uniform grades and standards, whether the standards are government grades or industry specifications. Hence, there is undoubtedly a place for public policies granting patent rights and the protection of trade-marks. The permission of imaginative and unique selling methods, if not fraudulent or misleading, may also help provide a favorable climate for product development. Informative advertising may, in fact, help increase product knowledge and sharpen quality-price comparisons.

But if differentiating factors are effectively protected, the profits from them will be capitalized into rents, and the process of product development may tend to be slowed. Competition from substitutable products is needed to assure that the profits from existing products will not persist and that new product development will be motivated.

In industries where, for very large outputs, unit costs would decline

[17] For an example of opposing industry points of view concerning federal beef grades, see Willard F. Williams, Earl K. Bowen and Frank C. Genovese, *Economic Effects of U. S. Grades for Beef*, Mktg. Res. Rept. No. 298, USDA, Jan. 1959.

as size of firm increased, severe price competition could reduce the number of firms in the industry to the point that serious monopolistic tendencies would result. Nevertheless, even under such circumstances, more emphasis on uniform grades and standards may contribute more than would be lost through change in the competitive structure of the industry. Appropriate public policies could be used to restrain possible tendencies toward undesirable industry performance under the changed structure. Furthermore, more rapid product innovation would tend to weaken monopolistic control of supplies of existing products.

Finally, government and other agencies concerned with economic advancement can undertake and support product development research, can encourage desirable directions of product change, and can present the results to industry in educational and service programs. Enterprising firms may find such information useful in developing and producing new products that satisfy wants more exactly and efficiently than products previously available.

NOTES

THE DILEMMA OF A LIBERAL ECONOMIST

JOHN W. HICKS
Purdue University

THE humanist is often found to anticipate by many years the social scientist, perceiving by a finer sense of understanding or "intuition" that which the latter grasps as a result of careful analysis. Certainly, when Robinson Jeffers wrote, in the 1920's,

> "While this America settles in the mould of its vulgarity,
> heavily thickening to empire,
> And protest, only a bubble in the molten mass,
> pops and sighs out, and the mass hardens."

he was anticipating the indictment which would be thrown heavily against our culture in the 1950's by a good number of people, among them at least a few sincere and careful scholars. Whether these critics must be considered to belong to a never quite thoroughly respectable underworld of socio-economic thinkers—as did, say, Douglas and Marx in their time—or whether they will eventually become the main stream of change, it is still too early to predict. Yet the general climate of disillusionment and doubt among intellectuals and "practical men" alike seems apparent enough that one cannot simply write off what has been and is being said by such as J. K. Galbraith, C. Wright Mills, Henry Steele Commager, William H. Whyte, and Aldous Huxley.

The picture which, in one form or another, they paint of "our America" is not one particularly to inspire confidence, or to which citizens of "man's last best hope on earth" might well aspire. And, to say the very least, some of the outward signs of our culture—our mass media, the pronoucements of our national leaders both political and industrial, the trend in our leisure habits, our celebrities—do not appear to contradict the impression these critics have gathered of our age.

The economist finds himself particularly sensitive to this criticism, for most of it boils down to a criticism of the basic framework and workings of the economic system. Phrase it as we may—and we have phrased it many ways over the past few generations—the real test of our economy has been and is now its ability to produce wealth. We have, of course, also worried about the distribution of this wealth once produced. But, in general, and impounding all else in *ceteris paribus,* that which has resulted in the production of more wealth has been judged "good"; that which results in less judged "bad." A kind of "social" profit motive has underlain the philosophy of the "individual" profit motive and justified

it. Now come the critics, who in the furthermost depths of their criticism throw doubt upon the appropriateness of this social profit motive, or at least point out by-products accompanying it which may be lethal to human freedom, perhaps to humankind. If they can succeed in destroying the economist's faith in the production of wealth, with what salt shall his food of life be salted?

* * *

It is perhaps unfair and improper to include Galbraith in the same category as the other critics, for nowhere does he really despair of the system. In fact, in his *American Capitalism*[1] he breathes the hope of a newly-born vintage of competition through countervailing power which may perform, in its own peculiar way, many of the functions of the "atomistic competition" so long gone save in agriculture. His main theme in *The Affluent Society*[2] is not that the production of wealth has led us to a sorry end, but that we have produced more of one type of wealth than we need at the expense of another type which would serve us better. Yet in the development of this theme, Galbraith exposes some of the generic frailties of our culture upon which the others also focus attention. Thus while perhaps more optimistic of a final cure, he nevertheless makes at least a partial diagnosis of the disease which the others, too, view with alarm. Galbraith is by no means alone in his views. Adlai Stevenson[3] and Adolph Berle,[4] to mention but two, have in recent writings taken very much the same stand with respect to the basic orientation of our production. Both seem to agree with Galbraith that more attention needs to be given to the production of hospitals, schools, recreation facilities and the like, and less to the further multiplication of consumer goods—particularly those which appease our desires for conspicuous consumption.

Whyte,[5] of course, concentrates upon what becoming an "organization man" does to people and to the communities in which they live. The modern corporation, he says, has brought with it a "social ethic" which, while perhaps virtuous in motive, nonetheless reduces the individual to a place of secondary consideration vis-a-vis the group, the corporation, or "society." While all this is done in the name of efficiency, and "the greatest good for the greatest number," the ultimate result may not be a happy one.

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[1] Galbraith, John K., *American Capitalism, the Concept of Countervailing Power*, Houghton Mifflin, Boston, 1952.

[2] Galbraith, John K., *The Affluent Society*, Houghton Mifflin, Boston, 1958.

[3] Stevenson, Adlai E., "Extend Our Vision to All Mankind," *Life*, May 30, 1960.

[4] Berle, Adolph A., Jr., "The Irrepressible Issues of the 60's," *Current Issues on Higher Education*, Association for Higher Education, National Education Association, Washington, D.C., 1960.

[5] Whyte, William H., *The Organization Man*, Simon and Schuster, New York, 1956.

Certainly, Whyte's organization man does not appear one who could or would take leadership in promoting economic growth, for growth involves imagination and vision. Both of these, save in minuscule quantities, appear *verboten* in the caricature he draws. And the "organization man," as described both in embryo and full development, seems less than an aggressive champion of freedom, economic or otherwise.

The indictment of our culture by C. Wright Mills in his book *The Power Elite*[6] is a severe one. Much of it revolves around what he considers our standard of values: that the real measure of success in America is the accumulation of wealth, no matter by what means one accumulates it. Thus the wealth accumulators, along with the warlords produced by years of hot and cold wars, form a small group of elite who are the real decision makers of society. According to Professor Mills, this "power elite" is an unfortunate one because it consists largely of men whose only qualification is that they have inherited or acquired money. They lack, says Mills, the principles and the basic moral character which leaders should have.

Commager appears to agree with Mills' critique at least with respect to where the power rests. Writing recently in the *New York Times* on the subject of why we lack statesmen in our present age, he says:

> If we ask what our young people are expected to admire and emulate, the answer is easy enough. The great rewards in our society go to the leaders of business, industry and finance. It is the business men, the bankers, the corporation executives, who run our communities. They are the men who sit on the boards of the universities, the hospitals, the orchestras, and the museums; they are the men who garner the richest harvest of honorary degrees from universities whose business is presumably scholarship.[7]

Aldous Huxley summarizes the basic points of Whyte, Mills and Commager in *Brave New World Revisited*,[8] when he speaks of over-population and over-organization as being the two forces most threatening to our freedom. Economists since Malthus have been familiar with the first, although there has been a resurgence of concern in recent times. As does Whyte, so Huxley views over-organization as an outgrowth of "economic efficiency." It is so much more "efficient" to deal with a "uniform product," even if that product be people. Thus "social engineering" which can act to make this human product more nearly uniform plays a greater role in our society. But what is the impact upon freedom? Says Huxley,

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[6] Mills, Charles Wright, *The Power Elite*, Oxford University Press, New York, 1956.

[7] Commager, Henry S., "Urgent Query: Why Do We Lack Statesmen?" *New York Times Magazine*, January 17, 1960.

[8] Huxley, Aldous L., *Brave New World Revisited*, Harper and Brothers, New York, 1958.

". . . man is a moderately gregarious, not a completely social animal. . . . A great gulf separates the social insect from the not too gregarious big-brained mammal. . . . Men cannot create a social organism, they can create only an organization. In the process of trying to create an organism they will merely create a totalitarian despotism."

Of even more concern is the possibility that our very ability to produce an affluent society will weaken our power to prevail against this despotism, for "if bread is supplied regularly and copiously three times a day, many . . . will be perfectly content to live by bread alone—or at least by bread and circuses alone." And certainly in the United States we have developed the productivity to provide this bread, along with meat, fruits, vegetables, and milk, canned, fresh, frozen, precooked, prepackaged, or dehydrated, to say nothing of circuses of every type and variety wherever and whenever the circus customer wants them delivered. And even if these fail in the long run to satisfy—if, as Huxley says, the cry of "Give me television and hamburgers but don't bother me with the responsibilities of liberty," changes to "Give me liberty or give me death,"—the interim during which television and hamburgers were adequate could well be long enough to work the wonders of dictatorship by the manipulation of minds and reflexes, which methods too have been produced by our marvelous science and technology.

Of these last, Huxley has much to say. The upshot is his contention that potential oppressors now have such subtle and wonderful methods of permanently converting other human minds to their purposes, that there is no reason why the really scientific dictatorship of the future should ever be overthrown.

* * *

Despite a difference in emphasis or perspective, a common thread can be seen running through the tapesty woven by a good many careful thinkers (many more than have been cited here), as they strive to depict the contemporary United States. It is a thread of contradiction—quite non-Marxian in nature—between the dream of the ultimate glory of an affluent society, and what really may be happening as we approach that state of affluence.

One of the wonders of our society has been its consumer orientation. And so oriented it has been, despite some charges to the contrary. This, indeed, has been one of the prime factors which has attracted liberal economists. Consumer orientation, coupled with the emphasis upon productivity and efficiency—continued growth—have resulted in a standard of living for most people far beyond anything dreamed in other lands and times. And we seem to be standing on the threshold of even greater plenty. This, too, has been attractive to the liberal economist.

But what is a "liberal" economist? First of all, of course, he is a "liberal" in the classical sense, whatever that may mean. The term has been much used and abused, but in the last analysis it resolves itself into an attitude concerning the freedom of the individual. But for the economist, "liberalism" can be more specifically identified. The liberal economist is one who, I submit, wants increased welfare for society; who thinks of this welfare as being at least partially expressible in terms of goods and services (tangible and otherwise), valued in a market; and who, with Pigou,[9] considers welfare as being increased whenever (*ceteris paribus*) (1) total national product is increased, or (2) there is a shift in distribution of the product in favor of the poor.

The contradiction with which the liberal is now faced is that the very ends he has sought may, in the course of being accomplished, bring lethal by-products. To maintain continued growth we must maintain consumption even to the point of driving people mad with the urge to find new and better wants. But even more critical, our phenomenal ability to produce "television and hamburgers" in such abundance for practically everyone—even now for many of the once poor; in two or three decades perhaps for all—may be giving the great opportunity to the potential oppressors and dictators who are with us always. Perhaps Keynes was correct in saying "it is ideas, not vested interests, which are powerful for good or evil." But in so saying he was assuming ideas to exist. In a world of infinite quantities of "bread and circuses," ideas may no longer be of interest until it is too late. The very affluence of the society along with its consumer orientation which has aimed at making a king of the "common man," may instead have turned him into a slave simply because gorged with "television and hamburgers" he no longer gives a damn!

If all of this is really true, it places the liberal economist in the most uncomfortable position of having to ponder the wisdom of a group he has always shunned and scorned: the fundamentalists. They long have argued that material progress is a false god which will lead one down the primrose path of dalliance and eventually straight to hell. Calling for a return to the good and simple things of life—the subsistance homestead, longer hours of harder work, less consumption, etc.—these fundamentalists have tended to irritate the liberal who has seen the "possibility of civilization" in increased productivity freeing man from the backbreaking, inhuman labor which has been the lot of the majority of humans through the ages. Certainly the opportunity of at least some leisure for contemplation and thought, for culture and education, did not appear as a false god. Certainly the quest to release human beings from the slavery of brutalizing labor could well be a gallant one. It has been the conserva-

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[9] Pigou, A. C., *The Economics of Welfare*, Fourth Edition, Macmillan and Company, London, 1950.

tives, the vested interests, who ever seemed arrayed against this attempt to allow man to attain the dignity and individuality which, in the Judeo-Christian tradition, was rightfully his. It was ever the liberal who tried to forge ahead in this direction.

Hence the dilemma of the liberal today, particularly if he is an economist. He still finds himself charmed by the logic of the discipline which has been created by his kind. He still believes, or wants to believe, in the market mechanism. The mechanism seems, as it more nearly approaches perfection, to be a wonderful way of getting the best use of resources in line with consumer desires. He still wants badly to have faith in the concept that, after all, individuals should have freedom of choice: even the freedom to be wrong. He knows well the imperfections of the mechanism, but he wants to believe that despite them the system works reasonably well, or at least better than any other of which he can dream. Perhaps by continuing to chip away at monopoly, at lack of knowledge, at immobility of resources, the machine can be made to work better. Perhaps there are "competition simulators"—countervailing power and the like—which will get the job done in wondrous though mysterious ways. Certainly if people become better educated, if freedom of thought and expression exist, if forces are allowed to balance each other, we will eventually muddle through. Perhaps, as some will say, there are always exploiters and the real problem is distribution. But even this can be solved. Workers of the world unite!

Yet if the web woven by the critics is a real one, even these last would fall to the doomful prophecies. For having lost their chains, to find instead "bread and circuses," the workers of the world would no longer care, and the chains would steal back again unnoticed and unfeared.

* * *

One may, of course, raise the question as to whether the critics cited are really correct in their analysis and conclusions. If they are not, then the dilemma evaporates and the liberal economist may return to his traditional labors. And the question is a valid one. Unfortunately, the answer is not immediately forthcoming. What "data" do exist are, in large measure, subjective in nature, at least with respect to their interpretation. After a good night's sleep, and most particularly on a bright and beautiful day, the writer finds himself less likely to accept Mr. Mills' or Mr. Huxley's outlook on our society than in some less "optimistic" enviromental situation. The really important thing is not that their unhappy view reflects reality as it actually exists now, but that it portrays a picture which could be, at some future time, an accurate one. If their words have any value, it is as a warning not yet too late to heed.

There have, of course, been prophets of gloom and doom in all ages. And somehow, despite or even partly because of them, man has continued

to make material progress. Perhaps he has even moved in the direction of greater freedom. That such a long-run trend has existed is comforting, although there is no guarantee of things remaining so. And, of course, such a secular trend does not alter the fact that some cyclical, or perhaps random variations may exist which, though finite in duration, nevertheless seem infinitely long to us who in the long run shall all be dead.

Does all of this then mean that the liberal economist must, in the last analysis, take the road he has always abhored? Like the fundamentalist, must he shun material progress for society because it can lead only to a diet of "bread and circuses" far too rich for humans in general? Is our experience beginning to indicate that, as economic growth proceeds beyond a certain point, it becomes directly contradictory to economic freedom, so that we can have more of one only by sacrificing increasing quantities of the other? If this be the case, then the liberal economist must surely change his stripes, for he has no longer a liberal dream to which to cling. His faith has always been that in the long run the possibility of more freedom could be best assured by more growth. In the light of mid-20th century cold reality, the seeds of doubt are sown. Can he be blamed for wondering if perhaps his best of all possible worlds is being slowly turned into a nightmare?

Yet, if he is a true liberal, I suppose he will gird up his loins to do battle, even against odds which appear overwhelming. For always in the depths of his mind will dwell the suspicion that his fears are really only an indication of his own shortcomings. Perhaps he is merely unequipped to deal with a fast changing world. Perhaps if he had the real intellectual and moral resources which one raised in the great Western tradition should have, he would know how to meet the future and conquer it!

And there may well be, in the liberal mystique, a way out of the apparent labyrinth of doubt. Affluence is by no means yet the lot of all the world. Even in our land the poor are with us still, though in a declining proportion. And certainly there are places where we could invest more—education, recreation, housing, health—and gain a positive social return. For this we have the means if we have the will. But for most of the rest of the world even the means do not exist. If we set ourselves to the task of increasing Pigouvian welfare throughout the world, in terms of greater total product and perhaps in a shift of distribution in favor of the poor (even though this meant from us to them), perhaps we could recapture some of the liberal fervor from days gone by.

Commager apparently was thinking of this possibility when he wrote:

> The men who won our independence and laid the foundations of the American nation were devoted patriots but they were, too, men of the world. For all the devotion to the nation they were creating, they were children of the Enlightenment. Reason taught them that all men were brothers, that purely national distinctions were artificial, and that there existed a great community

of arts and letters and philosophy and science cutting across and transcending mere national boundaries. The Declaration of Independence, it is relevant to recall, appealed to the opinion of Mankind, and asserted the Rights of Man.[10]

In truth, it may be the liberals who have failed. The ills of our society and time may stand only as a reflection of that failure. Bread and circuses need not conquer us unless we want them to! Television and hamburgers need not become the be all and end all of existence, if we take the trouble to seek something more worth while. Perhaps accepting the challenge of bread and circuses for all rather than for just ourselves, the chosen few, is the answer.

If, of course, the critics are correct, and the end point of affluence is enslavement, then to bring our gift of productivity to all nations will eventually end in their bondage too. "Today bread, circuses and slavery for America, tomorrow the world!" But at least our efforts may put off our own capitulation for a few generations, and perhaps in the interim we can somehow find a method of strengthening our defenses to save us from opulence and ourselves. This is a worthy challenge and the hope the liberal must cherish in his heart. Otherwise his only choice is to proclaim, with another melancholy poet:

> ". . . for the world, which seems
> To lie before us like a land of dreams,
> So various, so beautiful, so new,
> Hath really neither joy, nor love, nor light,
> Nor certitude, nor peace, nor help for pain."

This certainly is an epitaph no liberal would strive to claim.

[10] Commager, *op. cit.*, p. 36.

A NOTE ON THE ECONOMIC DEVELOPMENT OF EAST AFRICAN AGRICULTURE

DAVID WALKER
Makerere College, The University College of East Africa

THE purpose of this Note is to comment on the recent article by Dr. S. D. Neumark in this *Journal* from a viewpoint greatly influenced by the present state and recent history of agricultural development in East Africa.[1]

Against this background there is a great deal in Dr. Neumark's analysis which rings true and with which one agrees. It is, however, believed that Dr. Neumark has failed to mention certain factors and minimised others

[1] S. D. Neumark, "Some Economic Development Problems of African Agriculture," *J. Farm Econ.*, Feb. 1959.

By East Africa is meant the three British territories of Kenya, Uganda and Tanganyika.

that are crucial to an understanding of the economic development of African agriculture.

Resources

In considering the factors that have hampered and are hampering development, the basic geographical factors should not be ignored. This is such an obvious point to anyone at all familiar with African conditions that Dr. Neumark probably felt it not worth mentioning. Nevertheless, such factors are fundamental to an understanding of the position.

Consider, for example, the largest of the three British East African territories, the United Nations Trust Territory of Tanganyika which has a population of about nine million people and an area of about 350,000 square miles. Shortage of water and the problem of the tsetse fly are crucial factors limiting agricultural development.

Some years ago a careful enquiry into the water position revealed that from an agricultural point of view only 10 per cent of the land could be regarded as "well watered" and 8 per cent as "fairly well watered." About 20 per cent was regarded as "poorly watered" and no less than 62 per cent was recorded as being essentially without water. Although some improvement has taken place in very recent years the above figures give a fair picture of the position.[2]

The tsetse fly is endemic over the greater part of Tanganyika. Considerable areas in the west and the south in particular are quite badly infected and—unfortunately—these are areas which have at least a fair prospect of sufficient rain to support arable farming.

To really rid an area of tsetse fly requires—*inter alia*—a fairly dense and permanent settlement of farmers. In this connection and, indeed, in many other ways progress is hindered in many parts of East Africa by the lack of people! Though there are some areas particularly in Kenya where there is a fairly high population density—though not by Asian or West Indian standards—most of the area is under-populated and economic development is hindered thereby.

Then throughout East Africa the chemical quality of the soil is none too good. The not uncommon belief that all tropical soils are rich and have almost inexhaustible fertility is, of course, a myth. In actual fact the soils of East Africa with certain exceptions are often chemically defective and physically they display an all too easy tendency to erode and disintegrate under conditions of tropical sunshine and rain.

Closely connected with the basic natural endowments of the area is the general lack of knowledge of how to deal with many of the problems: problems concerned with various diseases of man, animal, and plant; with crop rotations; with optimum choice of crops; etc. A good deal of basic

[2] See, *East African Royal Commission Report*, cmd. 9475, London, 1955, especially Chapter XX.

agricultural research has, of course, been done over the years but in comparison with what has been done on agricultural problems in Europe or America or Australasia the work that has been done on problems of African tropical agriculture is quite minute. The tragedy that befell some cocoa growing areas in West Africa through swollen shoot some years ago is well-known, and similar tragedies in other parts of Africa are always possible. At the moment, in Kenya, for example, coffee berry disease is giving farmers and the Agricultural Department very considerable concern.

In his article Dr. Neumark stresses the potentialities for growth in African agriculture and his view that investment in communications and marketing facilities would enable these potentialities to be realised. Whilst not disagreeing with either of these views one must see the whole problem of agricultural development in East Africa against a backcloth of the region's natural endowments and the other matters we have noticed.[3]

One other point should be made relating to the natural resources position. Towards the end of his article Dr. Neumark mentions how inadequate communications may cause some areas to export labour rather than goods and he states: "The phenomenon of migrant labour is closely related to the comparative lack of transport and marketing facilities since workers can travel great distances on foot even when little else can reach the market."[4] This judgment surely gives far too much weight to transport considerations and far too little to the distribution of natural resources, on the one hand, and the accidents of history, on the other.

In East Africa the great movements of labour are to plantations and to the towns—mainly the former. Some plantations are situated where they are because geographical factors are particularly favourable; the main sisal estates of Tanganyika and the tea estates in Kenya are good examples of geographical influence. Others are where they are for what can only be called historical reasons; at a given date certain areas were alienated to non-Africans and have remained in non-African hands. It has for many years been virtually impossible in Uganda and Tanganyika for land to be alienated and thus there has been little scope for a radical change in the distribution of plantations in response to transport or other developments.

Similarly with the labour supply side. In contrast to what Dr. Neumark's analysis would lead one to suppose, there are areas which are well

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[3] In addition to the factors we have mentioned heed should be taken of the various natural obstacles to the development of communications in East Africa and the general health and quality of the labour force. Dr. Neumark mentions the problems that arise from the existence of "target workers" and the various social factors that inhibit economic enterprise.

[4] *Op. cit.*, p. 50.

served by communications (and reasonably well endowed from a natural resources point of view) which nevertheless export labour on a quite substantial scale. The high population density in the Nyanza Province of Kenya, for example, and the relatively small amounts of capital that are available there mean that the average income that can be earned on the land is relatively small even though the area is quite well off from a transport point of view; and workers find it profitable to travel some hundreds of miles to work in the plantations and towns of Uganda.

One also must not underestimate the distances that local produce travels at the present time when there is a demand for it. The trade in cattle and fish is extensive in East Africa. In Uganda cattle move on the hoof over a hundred miles from western Uganda to the Kampala market and compete there with cattle moved by train from the north. In Tanganyika fish from Lake Tanganyika finds its way to areas hundreds of miles from the Lake; and in West Africa dried fish may travel over a thousand miles by road before it is sold in the Kumasi or Accra markets. And, less spectacularly, in those areas where natural conditions permit a wide variety of crops to be grown within a reasonable distance of each other a substantial local trade has grown up, as one would expect from the theory of comparative costs. This is particularly notable in areas on the sides of mountains such as in the Bwamba/Konjo area on the Ruwenzori and in the Chagga areas on Kilimanjaro.

The point that seems to emerge from this discussion is identical with the point made earlier; important though communications are they are not *all*-important; in many cases they are not even a major factor. The flow of migrant labour must be seen as the resultant of the interaction of a whole set of economic, geographical, and social factors.[5] It is wrong to lay all the stress on transport and marketing facilities.

Subsistence Production

Dr. Neumark wishes to see the extension of the cash economy and the decline of subsistence production. In particular he wishes to see a great development of internal trade and specialisation. In the next section of this Note we comment on the general macro-economic factors that limit the expansion of internal trade. Here it is desired to discuss some of the micro-economic factors that operate at the individual farm level.

In the first paragraph of his article Dr. Neumark states that it is misleading to distinguish between "subsistence" and "cash" sectors. We would agree wholeheartedly with this judgment. Pretty well all African

[5] "Social" is mentioned as there is some evidence to suggest that migrant workers are attracted to the town by the desire to see the "bright lights," the desire to be near hospitals and schools, and because their friends and relatives have been there before them.

farmers in East Africa produce some crop or crops which they sell for money and all farmers produce most if not all of their own food.

The achievements of the peasant farmers of Uganda—using very simple implements—are quite amazing. In 1959, they produced and exported some 400,000 bales of cotton and some 90,000 tons of coffee; some 50 per cent of the total money national income came from the production and export of these two commodities. There is also considerable production of food crops for sale to the people living in the towns, or working on the non-African owned sugar and coffee and tea plantations. Indeed, the sort of specialisation in land use that has developed has gone a long way in the direction that Dr. Neumark would like. In the immediate vicinity of the main towns land is increasingly being devoted to the production of food crops for consumption and sale in the towns; sweet potatoes, plantains and vegetables. Further out there is a main cotton and coffee belt and further out again in the dry regions there is cattle raising where water and tsetse conditions permit.[6]

Nevertheless, all the farmers are growing their own food. Though producing a cash crop for the world market or for sale in the towns—and therefore being part of the money economy—all are subsistence farmers in the sense that they grow most of their own food; and there is no sign of any real change in this pattern.

In Kenya, too, there has been a reluctance to specialise completely. Dr. Raeburn has recently drawn our attention to the economic position of the typical peasant farmer (with about four acres) in one particular district of Kenya.[7] He considers that simple calculations of costs and benefits suggest that to maximise his income the farmer should use his land for coffee growing and buy his food elsewhere. Yet the typical peasant refuses to specialise and continues to grow his own food.

Though there may be some "economic irrationality" in the refusal to specialise there are some good economic reasons as well.

In the first place there is the security offered by growing food crops. Just as a more diversified export trade would be a safeguard for the economy as a whole so is a diversified farm a safeguard for the farmer. And the growing of one's own food constitutes a considerable amount of diversification. By specialising the farmer would be greatly increasing his various risks and uncertainties, and in African conditions—as we have

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[6] One powerful factor operating against any optimal use of land is, of course, the land tenure system and, in particular, the absence of any "rent" system. A depressing feature of travel in Africa is to see good land not being used and poor land being well used. The idea of rent as a payment that "ensures that land is used in the optimal manner" is strikingly brought home to one.

[7] J. R. Raeburn, "Some Economic Aspects of African Agriculture," *East African Economics Review*, Jan. 1959.

seen earlier—the *unavoidable* risks arising from the climate and unknown diseases are already very great.

Secondly, additional capital would be required in the real and burdensome sense of foregoing consumption if the farmer was to go over completely to coffee, as the period of gestation is long. Moreover, he would have to find *cash* to purchase his minimum requirements of food during the period of gestation and this would not be easy.

Closely associated with the two points made above, though not identical with them, is the effect of the farmer's personal (subjective) rate of interest. If one values money in the future very much less than money in the present then the prospects of a greater income in the future matched by a reduction in income during the gestation period is not particularly attractive. Our experience suggests that many government officials and outside observers fail to appreciate the very high rate at which the African peasant farmer discounts the future; and when one appreciates his poverty and the vast risks and uncertainties that beset him this is not surprising.

Thirdly, there is the common problem in Africa of the effects of the division of labour between the farmer and his wife or wives. In many parts of Africa wives are responsible for the food crops and the men for the cattle and cash crops and this can lead to certain peculiarities. It may well be that the wife will not "allow" the food garden to disappear or if it does she may well refuse to help with the cash crops.

Fourthly, there is no doubt that in many areas a combination of a cash crop with a food crop for domestic consumption is quite a good combination from a technical agricultural point of view. In the many areas of East Africa where the plantain is the staple food stuff, for example, coffee makes a very satisfactory complementary crop. And even in those areas where millet and cotton are grown the combination fits in well with the normal, traditional farming system.

It is considered, therefore, that there are strong and good reasons for the fact that peasant farmers cling to their "subsistence" production, and though agreeing with Dr. Neumark that economic development will mean the gradual shrinkage of these subsistence sectors it is not thought that any rapid change is likely.

Given the likely persistance of subsistence farming it is most desirable that attention should be given to ways of improving it, for considerable quantities of land and labour are involved in this production. Till very recently the Agricultural Departments in East Africa have concentrated attention almost exclusively on the cash aspects of farming and this to some extent may have had the effect of distorting the use of resources.[8]

[8] W. A. Lewis, "Economic Development with Unlimited Supplies of Labour" *Manchester School*, May 1954, especially pp. 149-150.

Paradoxical though it may seem, the best method of encouraging the production of cash crops may be improving the productivity of the land and labour engaged in subsistence production, thus releasing resources for other uses.

One last point. Changes at the farm level designed to increase the peasants' income almost inevitably involve him in more work and he is unlikely to respond enthusiastically to the Farm Planner's advice unless the increase in labour is likely to result in a more than commensurate increase in income. One of the problems in changing African agriculture is that often very much work is necessary to produce a relatively small additional early return.

The Development Process

In considering the development process Dr. Neumark lays particular emphasis on the role of transport and marketing improvements as factors likely to stimulate the growth of *internal* trade and specialisation.

The money economies of Uganda and Tanganyika are heavily dominated by their export sectors. As stated above something like 50 per cent of Uganda's money national income is derived directly from exports and when one takes into account the indirect effects of such earnings it is clear that the country is "economically dependent." Tanganyika is in a similar position to Uganda.

The suggestion of Dr. Neumark seems to be that an urban population can develop and demand the products of the agricultural sector almost independently of the level of foreign trade. We would dispute this in the case of Uganda and Tanganyika at the present time.

In these territories the dynamic element in the development process has been the growth of export crops and it is difficult to see how it could have been otherwise. Now, clearly, transport improvements are vital in this connection. Without the railway to Mombasa, Uganda could not export cotton and coffee. And even when the railway was built development was slow till the arrival of motor transport and roads, as the problem of moving the cotton crop on the human head to rail head was so immense.[9] Nevertheless, it is the export emphasis rather than the transport emphasis that seems to us the vital factor in the development process. This seems to happen in the following way.

An export crop is developed and money flows into the country. A substantial part of this money is spent directly or indirectly upon imports; the remainder plays a significant role in the development of inter-regional trade. As the export sector grows and the inflow of money increases there will be a tendency for local industries to be established in response to

[9] It has been estimated that in 1913 something like half a million head loads were necessary to move to the rail head the cotton output of *one* province. See C. C. Wrigley, *Crops and Wealth in Uganda*, East African Studies N.12, 1959, Kampala, Uganda.

the increase in the size of the effective market—and to some extent this can be encouraged by government policy. With the growth of local industry the level of inter-regional trade will grow but the growth both of local industries and of inter-regional trade depends in the last resort upon the growth of export earnings.

In Uganda and Tanganyika the money national income per head is less than £20 per annum, and the income of the average African peasant farmer is no more than about half this figure. In these conditions a "boot strap" operation is hardly possible, and the only *likely* way to reach a situation when it would be possible is to increase the level of exports.

A *possible* alternative way to break through the circle is large scale capital spending financed by the importation of capital. If considerable sums of money came into the country on capital account either under public or private auspices and was spent on development projects utilising local labour and materials then this could stimulate internal trade. And if supply elasticities were favourable a substantial increase in production could take place.

The prospects of large scale capital imports seem remote, however, and it is felt, therefore, that a concentration upon exports is the only possible policy to follow; appreciating, however, that if such a policy is successful increased inter-regional trade and specialisation will follow. Investments under the control of Government, and Government influence generally, need to be directed to the task of increasing the volume of exports.

A NOTE ON "HOW THE MARKING OF BEEF GRADES WAS OBTAINED"

WILLARD F. WILLIAMS
Oklahoma State University

IN A recent highly documented and cleverly written journal article, Rhodes traces the history of beef grade marking from about 1924 to about 1930.[1] Although I offer this as a critique on that article, I have no argument with the detailed "facts" presented therein; I am not interested in making a case for or against the official carcass grade standards for beef or the federal grade marking of that commodity; and I have no intention of criticizing factual results of consumer preference work on beef. The preference researchers at Missouri and elsewhere are to be complimented for their continuing work in this highly complex area of research. The work has been productive, and under the direction of skilled technicians such as Rhodes, it undoubtedly will eventually yield

[1] V. James Rhodes, "How the Marking of Beef Grades Was Obtained," *This Journal*, Vol. XLII, No. 1 (February, 1960), pp. 133-49.

results that will play an important part in shaping policies and practices on grading of beef and other meats.

My argument primarily is with Rhodes' interpretation of historical facts. I am disturbed by premature and implied conclusions drawn partly from a small piece of a large historical graveyard and partly from work which the author admits has produced "no completely satisfactory" answers.[2] Rhodes indicates that during the 1920's "the promoters (of grade marking) outran the researchers."[3] A careful reading of Rhodes' article seems to indicate that his "conclusions" have outrun his research results. This is particularly true of his four "historical lessons." Although the value of historical facts cannot be denied, it seems clear that Rhodes' article, and perhaps this note as well, tend to overemphasize the present day relevance of the early historical events discussed.

The author's stated purpose was to ". . . dispel any notions about a neutral role of grades in our economy."[4] But no responsible researcher with whom I am acquainted has argued that the federal beef grades are neutral in their economic effects. I doubt that anyone has expected them to be neutral because this would mean that they were utterly useless. Even the "typical textbook" treatment of grades and grading points out theoretical or expected effects on the allocation of production and marketing resources and on distribution and consumption patterns. Such allocations or reallocations and changes seldom, if ever, are neutral in their effects by regions, by type of producer, or type of marketing firm.

As pointed out elsewhere,[5] the federal grades for beef have tended to improve the competitive positions of independent packers, retail food chains and other large grocery retailers relative to the positions of the national packers, their sales branches, and other packers that depend heavily on private brands. They have contributed to the shift in the location of slaughter toward producing areas and to decentralization of slaughter within those areas. They probably have tended to increase relatively the production and consumption of well-fed (but not necessarily well-bred) beef. Whether or not this emphasis at retail on well-fed beef has hurt the remainder of the cattle-producing industry, however, is highly questionable. Certainly it has tended to increase the demand for feeder cattle and to reserve the demand for processed beef for producers of cows and bulls. The market for cows and bulls has been so strong in recent years that it is almost fortunate that more consumers were not demanding this beef for fresh consumption.

Without openly criticizing the present grade standards, Rhodes man-

[2] *Ibid.*, p. 149.
[3] *Ibid.*, p. 145 (my parenthetical insert).
[4] *Ibid.*, p. 133.
[5] Willard F. Williams, Earl K. Bowen, and Frank K. Genovese, *Economic Effects of U. S. Grades for Beef*, Mktg. Res. Rpt. No. 298, USDA (Jan. 1959), pp. 168-71.

ages to implant the following impressions: (1) the grade standards for beef as well as the practice of grade marking resulted almost entirely from the activity of producer pressure or "promotional" groups, (2) "Grades were definitely 'producer-oriented' in the sense that the promoters were primarily concerned with *benefits for producers,*"[6] as the primary motivation for grade marking of beef was ". . . an increased demand for well-bred and well-fed beef which would increase the derived demand for purebred beef cattle,"[7] (3) "The retail *marking* of grades was an entirely separate issue from the use of live and wholesale grades for price reporting,"[8] and (4) although "inadequate" and "inconclusive" research results ". . . should not prejudice our appraisal of present grade standards . . . ," and despite the fact that "research cannot solve valuation conflicts,. . ."[9] it is doubtful that the official grades and grade marking of beef have, or ever have had, any economic justification; as a matter of fact, they probably are slightly ridiculous.

That the grade marking of beef was influenced by producer promotional groups is unquestioned. The grade standards and grade marking, like most other public services, probably would not have developed in the absence of some type of promotion. Although promotional or pressure groups provide much of the motivation and spark for public services, including publicly supported marketing research work, this does not mean that the results necessarily are bad or that congressmen, administrators, and others do not consider and base their decisions on many aspects not considered or mentioned by the promotional groups. Furthermore, Rhodes himself points out that (1) the Board of Directors elected at the Kansas Better Beef Convention was not made up entirely of promoters for well-fed, well-bred beef,[10] and (2) a triangular conflict quickly developed in the grade marking controversy.[11] The participants in the conflict are described as the producer promoters of well-fed, well-bred beef, other beef-type producers, and packers. Thus, countervailing forces were in operation.

Rhodes' article deals explicitly only with the grade marking of beef. His history begins after the promulgation of the grade standards for beef. In such statements as "grades were definitely 'producer-oriented'," however, he seems to be considering the forces responsible for the establishment of the grade standards as well as the motivations for grade marking. In so doing, he fails adequately to recognize, in this article at least, the

[6] V. James Rhodes, *op. cit.*, p. 137 (Rhodes' italicization).
[7] *Ibid.*, p. 133.
[8] *Ibid.*, p. 147.
[9] *Ibid.*, p. 149.
[10] *Ibid.*, p. 139.
[11] *Ibid.*, pp. 140-41.
[12] See footnotes 6 and 7.

fact that the grade standards and the grade marking of beef were logical culminations of a long history of discussion, analysis and development. Dowell and Bjorka mention some progress in classifying and grading livestock in the period 1853 to the end of the Civil War.[13] The early pioneer studies at Illinois were motivated by a desire to establish a basis for trading at all market centers.[14] The problem was attacked from a national standpoint as early as 1915, when the market news service for livestock and meats was established by the U. S. Department of Agriculture.[15] A tentative classification of beef carcasses was adopted for market reporting purposes in 1917.[16] A wide variety of interests participated in the development of these early grade classifications. These included various agricultural state colleges, the Chicago Livestock Exchange, many packers, and several trade journals as well as many representatives of the U. S. Department of Agriculture.[17]

Kiehl reports that part of the interest in grading and standardization of meat during the period 1895-1920 grew out of general concern with the changing structure of the marketing system for meat.[18] Large-volume packers had developed in the latter part of the 19th century. During the first quarter of the century and particularly during 1918-20, producers as well as the public generally were concerned with the question of combination and monopolistic control of prices. This suggests that some congressmen and administrators, and perhaps others, could see that a uniform system of grade standards and grade marking might have some effects on industry structure and competition.

It seems logical to believe that the terms and specifications of the initial tentative grade classifications were not immediately and widely adopted by the beef trade, retailers, or consumers and that this severely restricted their usefulness in reporting and in interpreting prices. Dowell and Bjorka report that the task of establishing uniform classes was ". . . complicated by the pressure that was exerted to get the Department to adopt local terms in reporting individual markets."[19] A wide variety of local terms continue in use even today. In addition, these classifications were not considered entirely satisfactory as a basis for buying and selling livestock and meat, partly because they were tentative grade classifications rather than official standards. One source issued in 1923 indicates that

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[13] A. A. Dowell and Knute Bjorka, *Livestock Marketing*, 1st ed., McGraw-Hill Book Co., Inc., New York, 1941, pp. 286-87.
[14] *Ibid.*, p. 288.
[15] *Ibid.*, p. 290.
[16] *Ibid.*, p. 292.
[17] *Ibid.*
[18] E. R. Kiehl, *Consumer Evaluation of the Product Characteristics of Beef*, unpub. Ph.D. diss., Harvard Univ., March 1958, p. 63.
[19] A. A. Dowell and Knute Bjorka, *op. cit.*, p. 292.

". . . standard specifications for the *purchase* of this commodity are generally needed. The demand for this service has continued to increase."[20]

Using the classification adopted in 1917 as a basis, the Department, accordingly, elaborated a more complete classification of livestock and dressed meats. Descriptions of these classifications were made generally available and all interested firms and individuals were requested to consider the adaptability of the specifications to their needs and submit any pertinent criticisms or suggestions.[21] It is significant that the first tentative and official grade standards were issued for carcass beef. This was in June, 1923, two years prior to the adoption of tentative and official grade standards for market classes and grades of slaughter cattle and about one year prior to the beginning of the period with which Rhodes deals in his article.

In view of these considerations it appears, first, that there were many reasons why official carcass grade standards were developed for beef. The need for these standards in market price reporting certainly was one of these reasons. Second, it seems there is little evidence that Sanders and the producer promotional groups dictated the nature and character of the beef carcass grade standards. Tentative standards had already been adopted when Sanders and the promotional groups became active. Third, the advent of grade marking was not entirely unrelated to the felt need for more widely used and better understood grade terms and descriptions for use in price reporting. Fourth and more important, once adopted, the standards tended to circumscribe and limit the activities of the producer promotional groups. The producer promotional groups undoubtedly affected the timing involved and exerted pressure as described by Rhodes. Personalities and particular promotional ideologies, however, probably did not greatly affect the eventual result. The alternatives at this time were few and clear-cut. Basically they were: should or should not the Department initiate a grading and stamping service based upon the then existing carcass grade standards. Fifth, no evidence is cited by Rhodes which indicates that the grade marking of beef could have been expected to promote purebred cattle or that it has, in fact, done so. Some promotional groups probably had this aim in mind, assuming, as Rhodes seems to have done, that (1) only purebred cattle can qualify in terms of quality and conformation for Prime and Choice, and (2) nearly everyone would consider these grades as best and preferred for all purposes. In retrospect, I seriously doubt that purebred beef cattle producers have benefited from grade marking more than other beef producers.

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[20] Division of Livestock, Meats and Wool, BAE, USDA, *Specifications for the Purchase of Fresh and Frozen Beef* (tentative form), April 1923, p. 1 (my italicization).
[21] *Ibid.*

Rhodes indicates that although ". . . some . . . promoters were aware that in order to derive benefits for producers, grades must have meaning in terms of consumer acceptability . . .[22] the only reason that consumer preferences were discussed was the confidence that they were consistent with the desire to promote well-fed purebred beef."[23] There was ". . . the prevailing supreme confidence (particularly in the U. S. Department of Agriculture) that adequate knowledge was already possessed to label beef for consumers as to eating quality,"[24] and ". . . evidence of a smug superiority (among industry promoters) that consumer objection to fat beef was due to ignorance."[25] Rhodes correctly notes that ". . . present political forces concerning grading have drastically altered since the beginning of grade marking."[26] Nevertheless, he implies that the grades for beef and the grade marking of this commodity still are designed primarily to promote well-fed and well-bred beef,[27] and that the present grades are "so heterogeneous in eating quality" that it is highly doubtful that they bear any relation to consumer preferences.[28]

I am not going to argue each of these points. I simply want to point out that in retrospect, no one, including Rhodes, believes that the industry should have delayed grade marking until "adequate" research data were available. Rhodes says that "presumably only the very naive will be shocked at learning that an official standard was based upon entirely inadequate research."[29] But other statements in this and others of his publications,[30] including those quoted above, indicate that Rhodes himself has been thoroughly shocked by this realization. Lack of consistent and definitive research results forces Rhodes to admit that the "promoters exercised excellent judgment in failing to wait for the researchers; they would not have been wholly satisfied."[31]

The combined talents of educators, the industry, and government had been drawn upon in establishing the standards. The final decision, it is true, was determined partly by the assumption that degree of finish and quality were positively related in some manner. This seemed like a reasonable assumption at the time because finish was one of the few factors

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[22] V. James Rhodes, *op. cit.*, pp. 137-38.
[23] *Ibid.*, p. 149.
[24] *Ibid.*, p. 137 (my parenthesis).
[25] *Ibid.*, p. 138 (my parenthesis).
[26] *Ibid.*, p. 149.
[27] This is accomplished principally by dealing historically only with the period 1924 to about 1930 and then raising questions regarding present-day implications of the historical developments.
[28] V. James Rhodes, *op. cit.*, various statements, pp. 147-49.
[29] *Ibid.*, p. 149.
[30] See particularly V. James Rhodes, Elmer R. Kiehl, *et al., Predicting Consumer Acceptance of Beef Loin Steaks,* Mo. Res. Bul. 651 (Jan. 1958), p. 6.
[31] V. James Rhodes, *op. cit.*, p. 145.

that could be subjectively measured. That it was reasonable is attested to by the fact that we cannot say definitely even today that it has no factual basis. Grade standards based entirely upon finish would have provided the trade and consumers with a basis for discriminating and selecting from among alternative levels of at least this one factor. But even the earliest tentatively official grade standards were not based entirely on finish. Four factors, conformation, thickness of flesh, finish, and quality were considered.[32] At present, finish is not directly considered by the carcass grade standards for beef. This factor finds its way into these standards only through emphasis upon marbling and conformation.[33]

Regardless of whether or not the assumptions involved were correct, some credence must be given to the following statement by Dowell and Bjorka:

> Producers recognized the importance of setting up the necessary machinery whereby consumers could be certain that they obtained the grade of meat actually ordered and paid for. They believed that the sale of beef on a quality basis would be reflected in the price paid for the live animals, and hence the producer would be paid in accordance with the quality of the livestock delivered at the market place.[34]

The idea that grade marking would permit consumers to select leaner meat as well as the more highly finished product was at least considered. In addition, the Department and the industry are to be highly commended for generally recognizing, as early as 1917 in establishing the tentative standards, ". . . that the class and grade terms used to describe slaughter animals should be related to the resulting carcasses."[35]

Rhodes points out, correctly I believe, that a secondary objective of grade marking was to "stop retailer misrepresentation."[36] But he thinks that under today's marketing conditions beef grades are "somewhat superfluous . . . as a deterrent to 'quality misrepresentation'."[37] The advent of large-scale retailing and emphasis upon quality repeatability, he indicates, makes grade marking for this purpose unnecessary. But not all large-scale retailers, even those that emphasize quality repeatability, are above misrepresenting quality; not all retailers are large in scale; not all emphasize quality repeatability; and not all livestock and meat han-

[32] Division of Livestock, Meats, and Wool, BAE, USDA, *Specifications for the Purchase of Fresh and Frozen Beef* (tentative form), April 1923.

[33] For a diagrammatic interpretation of the federal carcass grade standards for beef and a description of the factors specified in these grade standards and of their application in grading see Willard F. Williams, Earl K. Bowen, and Frank Genovese, *op. cit.*, Appendix, pp. 184-89.

[34] A. A. Dowell and Knute Bjorka, *op. cit.*, p. 308.

[35] *Ibid.*, p. 292.

[36] V. James Rhodes, *op. cit.*, pp. 142 and 147.

[37] *Ibid.*, p. 147.

dling firms are retailers. Grade marking undoubtedly has improved the knowledge of all types of handlers including producers, livestock buyers and sellers, packers, wholesalers, retailers and consumers regarding animal and/or carcass characteristics associated with the grade terms in use. Grading has tended to equalize this knowledge among buyers and sellers as well as raise the general level of knowledge. In this sense, then, grades have performed an important service in deterring both conscious and unconscious "quality misrepresentation" at each level of the trade and there is little reason to believe that they can no longer continue to perform this function. It is partly for this reason that prices, pricing, and market news reporting certainly must have played an important role in the drive for official grade standards and for grade marking on beef. It must have at least occurred to many people, within and outside the U. S. Department of Agriculture, that the grade marking of carcasses would affect the accuracy and effectiveness of the reported carcass and live animal prices, tend to establish a uniform language in the trade, and increase the level and uniformity of knowledge among buyers and sellers. Misrepresentation takes place in terms of both quality and price.

Rhodes indicates further that although the promotional interests representing well-fed, well-bred beef are still active, the really black-hearted promoters are now the retailers.[38] While criticizing economists for being quick to give their value judgments he suggests that they look askance at the "affecting-consumer-demand-via-retail-marks function" of beef grading.[39] He emphasizes the point, indicating ". . . that use of retail grade marking as a promotional device is likely to discriminate against certain areas and types of production."[40] This is true and widely recognized, but it is also recognized that given a set or sets of preference structures, almost any conceivable grading scheme is likely to discriminate in some manner. Later, on the same page, it becomes clear that the argument is another of Rhodes' straw men. He says, "It appears possible that the present impact of grades as a promotional device is being exaggerated by many participants in the present controversy."[41]

As pointed out in another publication, retailers' advertising and merchandising policies, in recent years at least, have been tied closely to the federal grade standards.[42] These policies, particularly opportune in a period of high consumer incomes, have influenced consumers' buying patterns. The evidence developed by Rhodes and others, however, does

[38] *Ibid.*, pp. 148-49.
[39] *Ibid.*, p. 148.
[40] *Ibid.*
[41] *Ibid.*
[42] Willard F. Williams, Earl K. Bowen and Frank Genovese, *op. cit.*, pp. vii and 165-67.

not indicate that consumers have been influenced in a direction contrary to their basic desires and preferences. This and other information suggests that for many, perhaps even most, consumers the choice grade might represent the most satisfying compromise from among the federal grades. It is doubtful that the promotional efforts of the retailers would have been so successful if this were not true.

This is not to say that the U. S. carcass grade standards for beef should not be thoroughly revised or that they should not be continuously revised as new research results are developed and tested. Whatever the forces responsible for the development of the carcass beef grade standards and the grade marking of beef, they were developed; a beginning was made. While the results may not seem fully satisfactory, or at all satisfactory to some, many of the early initiators and even some of the promoters are to be admired for their initiative and foresight. These men lacked experience with grades and grading and were forced to proceed on the basis of assumptions because dependable research results had not been forthcoming. Until such results are available, the industry and the Department must continue to make decisions with regard to grades and grading on the basis of assumptions and intuitive judgments. As Rhodes states, "There is rarely universal agreement as to the implications for our time of a record of past events,"[43] and in the present instance we are well advised to walk softly until such time as we can offer something more constructive than is available at present.

During the next year the ever smoldering embers of the grading controversy probably will flame anew. The beef industry is aware that after several years of work the Department's Livestock Division is preparing some revised carcass beef grade standards for industry consideration. Interested groups, including the American Cattlemen's Association and the Western States Meat Packers Association, have formed committees to study the question thoroughly and to work for revisions. This is likely to touch off another round of inquiries into various technical aspects of the official grades for beef and into their economic effects. Real progress and improvement will call for the combined cooperation of researchers, the administrators, and the industry. On particular aspects of proposed new programs, researchers will be in position to offer valuable guidance and judgment if they conduct themselves in such a way that their comments and suggestions will be solicited. Articles of the type I have reviewed here are not likely to impress the administrators and others that the researchers have much to offer.

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[43] V. James Rhodes, *op. cit.*, p. 147.

REPLY TO WILLIAMS

V. JAMES RHODES
University of Missouri

FIRST, I shall restate my interpretation of the present relevance of the history of grade marking. Then I shall deal with a few specific points of Dr. Williams. In addition, I shall attempt to alleviate his worries concerning my attitude toward grading and promotion. Much of his criticism appears to stem from a misinterpretation of my attitude. Unfortunately an adequate understanding of grade tagging involves a considerably longer discussion of *present conditions*—as well as those of the 1920's—than has been, or can be, given by either of us in this exchange.

Grade Marking

The practice of marking grades on beef carcasses began in 1926-27 at the request of a primarily producer group known as the Better Beef Association. The most articulate spokesman of this group, Alvin Sanders, argued that many customers were prevented from buying better quality beef by eating places and retailers who failed to carry the better quality and/or palmed off very poor quality meat instead. To promote the sale of "better beef," this group conceived the idea of tagging it. After much discussion and not a little controversy, it was agreed that the Federal Government should do the "tagging" and that it should use the grade terms and specifications already in use for price reporting purposes.

It is relevant to emphasize that the use of grades for the purpose of price reporting was developed entirely independently and prior to the marking of grades on carcasses. This separate development leads to two observations: (1) that the usefulness of grades for price reporting is independent of whether they are or are not marked on the beef; (2) that the purposes of *grade marking* are promotional and/or educational.[1]

The Midwestern promoters rather clearly indicated their purposes by obtaining the marking of only Prime and Choice, which since have been consolidated into today's Prime grade. The Western cattlemen fought strongly but unsuccessfully for marking of all grades since they wanted their sub-Choice steers and heifers to receive a tag distinguishing them from dairy animals, beef cows, etc. Thus the promotion of grade tagging and the initial marking of only the two upper grades both indicate the process by which Midwestern breeders and feeders attempted to serve their own interests. It was the producers' attempt to use grades to serve their own interests which I described by the term "producer oriented

[1] I recognize a degree of overlap of these two terms, but the distinction can be clearly made in this particular historical situation.

grades." Williams is correct in pointing out that the grade specifications, themselves, were not written by the producers. The midwesterners found specifications acceptable as they stood. I did not debate the question of whether grades *should* be producer-oriented, but I think there can be no sensible debate as to the purposes which the promoters expected[2] grade marking to serve.

The opposition of large packers to federal marking of grades and their rapid development of their own brands is revealing. A set of producers was trying to obtain market advantage by reaching past the retailer to the consumer with federal quality markings on beef. It appears that packers then found it expedient to develop their own means of obtaining market advantage by using private brands to reach past the retailer to the consumer. The later development of chain retailer market power suggests that neither producers nor packers are very successfully obtaining market advantage by trying to reach past retailers to consumers with their grades and brands. This is the conclusion I had in mind—and perhaps should have so indicated—when I stated, "It appears possible that the present impact of grades as a promotional device is being exaggerated by many participants in the present controversy."[3] In my opinion, some industry opponents of grading and also William's Research Report No. 298 both vastly overstate the effects that grades versus private packer brands now have upon the relative market power of large and small packers and of packers versus retailers. Most retailers now buy by specification. Is there any reason to think that they would cease that practice and become docile purveyors of packer brands if there were no tagging of grades? I am not suggesting that marking of grades should cease; I am suggesting that such cessation would not have the large effects on market power often claimed by *both the supporters and opponents* of grade marking.

Some Specific Points

Williams disagrees with my statement that "the advent of large-scale retailing and the current retail emphasis upon quality repeatability probably render somewhat superfluous the need for retail grade marking as a deterrent to quality misrepresentation."[4] Which of us is more nearly correct is an interesting empirical question. Prerequisite to a study of the degree of quality misrepresentation is a definition of what we mean by "quality" and by "quality misrepresentation" in the case of beef.[5]

"The ever smoldering embers of the grading controversy probably will

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[2] There is room for considerable debate as to the purposes grade marking actually does accomplish, but that is a different story.

[3] "How the Marking of Beef Grades Was Obtained," p. 148

[4] *Ibid.*, p. 147.

[5] Our research results indicating what we find beef quality to mean to consumers may be found in Mo. Res. Bul. 651, 652, 676, and 677.

flame anew," according to Williams.[6] The current industry controversy about grading is not about the use of grades in price reporting; it is about the marking of grades on beef cuts for the use of many retailers in their merchandising. An industry controversy about shifting the grade boundaries of grades used only for price reporting is hardly conceivable; a controversy now exists about changing the boundaries of a grade (Choice) merchandised by several chains, because the change might affect considerably the types of beef most in demand.

I place so much emphasis upon this elementary distinction between grade standards and grade marking, because apparent failure to make this distinction has led to some of William's confusion. For example, his long paragraph on the "reasons why official carcass grade standards were developed for beef"[7] is evidently intended to be a criticism of my article. However, his paragraph is largely on a different topic because standards and tagging were, and are, different subjects.[8]

I am sorry if my contrast of research findings with the opinions of promoters and USDA officials in the late 1920's suggested a lack of admiration for those worthies. Disrespect was not intended. However, I think the history of this particular period does much to explain erroneous ideas about grades and qualities held in many circles until very recently. Present day consumer acceptance research at Missouri and other Stations has found the eating qualities of most Good and Choice beef to be very similar. Very often in the past 5 years I have encountered the propositions that (1) Choice beef is consistently better than Good and (2) that past research revealed that conclusion. Numerous quotations in my paper demonstrate that the Better Beef promoters and several USDA officials vigorously stated Proposition (1). My review of the important Cooperative Meat Investigations in the late '20's and early '30's demonstrated that Proposition (1) was not concluded by researchers. I am sorry that Williams finds this conclusion so unpalatable and that he insists upon the inconsistency of our consumer acceptance research results. He generously allows that our work "will eventually yield results"[9] of importance which obviously indicates that it has not yielded any yet. Interested readers are invited to study the relevant publications.

Grading and Promotion

Williams apparently feels that my discussion of the origins of the marking of grades and of the promotional purposes of the leaders concerned

[6] *Supra*, p. 886.
[7] *Supra*, p. 882.
[8] Both subjects are discussed in Elmer R. Kiehl and V. James Rhodes, *Historical Development of Beef Quality and Grading Standards*, Mo. Res. Bul. No. 728, Feb. 1960.
[9] *Supra*, p. 878.

was a subtle—or not so subtle—attack upon the integrity of grades. He has me imply that promoters are "black-hearted."[10] Perhaps it will help clear the air for me to state my beliefs that: (1) promotion, in itself, is an accepted technique on the American scene, and I admire the initiative and imagination shown by Sanders and his fellow promoters of the Better Beef Association; (2) federal beef grades leave much to be desired but they are hardly "ridiculous" nor do they lack "any economic justification"[11] and I have never used those terms.

[10] *Supra*, p. 885.
[11] *Supra*, p. 880.

A NOTE ON ANALYTICAL MODELS; THE NEED FOR CAUTION IN ASSUMPTIONS AND DATA USE

ROY G. STOUT
*Agricultural Marketing Service**

IN AGRICULTURAL economics considerable emphasis has been placed in recent years on mathematical model building and econometric analysis. Basically, this is beneficial to the profession. However, there is danger that the analyst may become so engrossed in model building that he fails to guard against erroneous conclusions resulting from using improper or questionable data. A sound structural analytical framework is essential, but the final analysis depends as much on the data analyzed within this framework as on the analytical structure itself. Consequently, the appropriateness of the data injected into the model must be carefully examined if the results are to be of any use in making practical decisions. The use of questionable data may, in fact, cause undue criticism of a perfectly good analytical technique. For instance, some persons have judged that linear programming is not very useful because the price or yield information used in the programs was not realistic. Properly, the criticism should have been directed at the input coefficients and not at the technique of linear programming.

Judge and Wallace[1] in a recent report on spatial equilibrium analysis apparently failed to investigate the appropriateness of some of their data; otherwise, it is hard to understand why they did not make proper adjustments for certain realistic factors. There are four points that deserve comment.

* Opinions expressed herein are those of the author and not necessarily those of the Agricultural Marketing Service.

[1] G. G. Judge and T. D. Wallace, *Spatial Price Equilibrium Analyses of the Livestock Economy: 3. Spatial Price Equilibrium Models of the Pork Marketing System*, Okla. State Univ. Tech. Bul. T-81, Jan. 1960.

TABLE 1. REGIONAL PER CAPITA PORK CONSUMPTION ESTIMATED BY JUDGE AND WALLACE, 1955[a]

Region	States Included	Per Capita Consumption	Percent of U. S.
		pounds	
1	Vt., N. H., Me., Mass., Conn., R. I.	73.8	110.5
2	N. Y.	79.4	118.9
3	Md., Del., D. C., Pa., N. J.	72.9	109.1
6	Mich., Ohio	75.2	112.6
7	Ill., Ind.	77.2	115.6
8	Minn., Wisc.	65.2	97.6
9	Nebr., Iowa	60.4	90.4
10	Kan., Mo.	65.6	98.2
15	N. Dak., S. Dak.	51.7	77.4
16	Wash., Ore.	67.1	100.4
17	Mont., Idaho	60.4	90.5
18	Wyo., Colo.	64.2	96.1
19	Utah, Nev.	62.2	93.1
20	Ariz., N. M.	55.6	83.2
21	Calif.	77.2	115.6
4	W. Va., N. C., Va.	51.5	77.1
5	Ky., Tenn.	49.3	73.8
11	Ala., Ga., S. C.	47.7	71.4
12	Fla.	60.3	90.3
13	Ark., Miss., La.	45.2	67.7
14	Okla., Texas	59.1	88.5
South	States in regions 4, 5, 11, 12, 13, 14	52.0	77.8
U. S.		66.8	100.0

[a] Judge and Wallace, *op. cit.*, computed from Tables 21 and 31, pp. 6 and 10.

One is estimates of regional pork consumption. Historically, the population of the Southern Region have been well-known as pork consumers. Surveys in several cities by the Bureau of Human Nutrition and Home economics in the spring of 1948 and the Household Food Consumption Survey conducted by the U.S. Dept. of Agriculture in the spring of 1955 substantiate the relatively high level of pork consumption in the South. Per capita urban consumption of pork in the Southern cities included in the 1948 study was about 12 per cent above the average for all cities surveyed.[2] The 1955 survey estimated that per capita consumption for all residence locations in the South exceeded the U.S. average by about 12 per cent. The urban average was 18 per cent higher than for urban U.S., the rural nonfarm average was 6 per cent higher than the U.S. counterpart, and the farm average was 2½ per cent lower than the U.S. farm average.[3]

[2] J. C. Purcell, *Prospective Demand for Meat and Livestock in the South*, Marketing Res. Rept. No. 99, U.S. Dept. Agr., and Southern Coop. Ser. Bul. No. 43, Oct. 1955, Table 8, p. 12.

[3] Harold F. Breimyer and Charlotte A. Kause, *Consumption Patterns for Meat*, U.S. Dept. Agr., AMS-249, May 1958.

Per capita pork consumption by regions estimated by Judge and Wallace is shown in Table 1. Regions 4, 5, 11, 12, 13, and 14 include 14 of the 16 states designated as the Southern Region in the USDA Survey of 1955. The consumption estimates by Judge and Wallace for these areas varied from 67.7 per cent of the U.S. average (Ark., Miss., La.) to 90.3 per cent (Fla.), in contrast to the 112 per cent from the USDA Survey. Per capita pork consumption for the U.S. was estimated by Judge and Wallace to be 66.8 pounds. Their estimates for the Southern states average 52.0 pounds. Assuming consumption in the South to be 112 per cent of the U.S., per capita consumption for 1955 would be estimated at 74.8 pounds—about one-third more than the estimate by Judge and Wallace.

The significance of these differences is sharply focused by the statement by the authors on page 22 that in 1955 about 20 per cent more pork was slaughtered than consumed in Georgia. Consumption estimates for Georgia using the average consumption for the South from the USDA Survey (state figures have not been tabulated) indicates that Georgia was about 7 per cent deficit in slaughter relative to consumption in 1955.

Similar differences exist between the estimates for other regions. For example the USDA Survey estimated that average consumption in the Northeast Region was about 86 per cent of the U.S. average. Average consumption estimates by Judge and Wallace were from 109 to 119 per cent of the U.S. (Regions 1, 2, 3 in Table 1).

Basically there are two, and perhaps three, reasons for these differences in consumption estimates: (1) the declining demand for pork; (2) differences in consuming habits by geographic regions, and (3) possibly the different levels of farm slaughter in the different areas.

Judge and Wallace developed a demand equation for pork for the United States and assumed it would properly reflect consumer behavior in each of the regions. Then they used this same demand function to estimate consumption in each region. This model was based on time series data for the years 1925-1955 (excluding 1942-1946) and generated an income elasticity of .86. Since per capita incomes in the South were low relative to the nation this resulted in low per capita consumption estimates for the Southern areas. This high income elasticity also explains the high consumption estimates in the Northeast.

Luby[4] gives several reasons and graphically shows that there has been a considerable decline in the demand for pork from 1948 to 1955. Shepherd and others[5] found that for the years 1910-1952 the ratio of beef cattle prices to hog prices increased while the ratio of beef consumption to

[4] Patrick J. Luby, "Declining Demand for Pork—Reconsideration of Causes and Suggested Prescription for Remedy," *J. Farm. Econ.*, 40:1832, Dec. 1958.

[5] Geoffrey Shepherd, J. C. Purcell, and L. V. Manderscheid, *Economic Analysis of Trends in Beef Cattle and Hog Prices*, Iowa State Col. Res. Bul. 405, Jan. 1954.

pork consumption remained about the same. This indicates a declining demand for pork relative to the demand for beef.[6]

The increase in incomes and the decline in demand for pork during the years since about 1948 raise some question regarding the reasonableness of the .86 income elasticity. In fact, the time period utilized to generate the demand equation by Judge and Wallace may be the real weakness in their analysis of the market in 1955. They did, wisely, eliminate the war years. Looking at the remaining years, per capita levels of pork consumption were low during the depression period of 1930-1940. But was the real reason low income, which did exist during that period, or was it the low state of productivity in the farm sector due to severe depression and drought that failed to produce pork? In the post-war years (1946-1952), there was a backlog of buying power and levels of beef slaughter were relatively low. This leaves only 5 years in the 1920's and 3 years in the 1950's that even approach a normal situation. Thus the period used by Judge and Wallace reflected an abnormal demand structure for pork that, when applied to 1955 (a year they assumed to be normal) would undoubtedly generate unrealistic consumption estimates.

Breimyer and Kause, in analyzing the data from the USDA Survey, showed that the relation of income to quantity of pork consumed is quite different for the different regions of the United States. In fact, they concluded that only in the Western Region did income and quantity consumed vary directly. In the South, as incomes increased there was a decline in consumption of pork and an increase in the consumption of beef.[7] This difference in income-consumption relations by regions indicates the need for the development of demand equations for pork by regions if the flows from the spatial equilibrium model are to provide an adequate benchmark to evaluate the present marketing system.

Perhaps another factor of importance is farm slaughter in the South. The 14 Southern states account for nearly 50 per cent of the total farm slaughter in the nation. The per capita farm slaughter (based on total population) in 1955 was about 12 pounds in Regions 4, 5 and 11. The per capita farm slaughter (based on total population) for the nation was about 4.8 pounds. In 1930 the per capita figures were about 31 pounds in the South and 16 for the Nation. Thus the influence of farm slaughter has been shifting towards the South. In the spatial analysis, Judge and Wallace added farm slaughter to commercial slaughter to obtain a total

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[6] Other reports treating the declining demand for pork include: (1) Gerald Engelman and Raymond O. Gaarder, *Marketing Meat-Type Hogs, Problems, Practices, and Potentials in the United States and Canada*, U.S. Dept. Agr., AMS, Marketing Res. Rept. No. 227, April 1958; (2) J. C. Purcell, *Analysis of Hog Prices on Georgia Markets*, Ga. Exp. Sta. Bul. N. S. 62, Experiment, Ga., Aug. 1959.

[7] Breimyer and Kause, *op. cit.*, p. 18.

pork supply estimate for each region. In doing this they implicitly assumed that farm slaughtered pork and commercially slaughtered pork are perfect substitutes. This in turn assumes that the price and income elasticities are the same for farm slaughter as for commercial slaughter. This does not seem likely. Research regarding this point could prove very enlightening. It was not possible from reading the publication to determine whether farm slaughter quantities and prices were included in the derivation of the demand equation by Judge and Wallace.

The second point to be commented on may be considered of minor importance; however, it does illustrate the lack of realism in Judge and Wallace's analysis. On page 14, the authors show their optimum pattern of shipments of live hogs from producing areas to slaughter areas. This optimum pattern shows live hogs moving from the Omaha, Nebraska, shipping center to points such as Boston, Massachusetts, and Portland, Oregon, for slaughter—distances of about 1,500 and 1,700 miles respectively. Some hogs actually do move as far as Nebraska to California. But it is doubtful that the transport rates used in the analysis are proper to such long hauls. First, there is a 36-hour limit in which livestock can be in transit without rest, feed, and water. Therefore, if the animals do not make the trip within this length of time, a charge for feed, water and labor should be added to the transport costs. In making such a long trip, there undoubtedly will also be an excessive amount of shrinkage and bruising of the animals.

The third comment relates to the discussion by Judge and Wallace on the evaluation of the locational efficiency of pork slaughter. First of all, it is rather naive to consider slaughter plant location for the entire packing industry based on hog slaughter alone. A high percentage of packing plants slaughter both cattle and hogs; consequently, before the efficiency of plant locations is evaluated, a dual model of cattle and hogs should be considered.

The authors use the sum of the costs of the optimum movement pattern of hogs to slaughter plus the cost of moving pork from slaughter centers to consuming centers as the indication of minimum cost under the present locational array of plants. The alternative is to slaughter all animals where they are produced and ship only pork. This would reduce the tonnage moved by approximately 40-45 per cent. Allowing for the 1,500-1,700 mile trip for hogs which the optimum movement pattern for hogs indicates, the transport cost difference between the 1955 locational pattern of slaughter facilities and a production-oriented pattern was approximately 13 cents per hundredweight (live weight basis) less for the latter. The main criticism here is that this minimization of transport costs was the only factor considered by the authors in evaluating locational efficiency, when transportation costs probably account for not more than 15 per cent of the total cost of processing.[8] They should at

least have acknowledged that other factors are important in evaluation of plant location, even though empirical data for evaluation were not available. Such items as geographic differentials in wages; investment in buildings, equipment, and land; power costs; and live animal assembly costs are a few items that will undoubtedly have a large effect on locational efficiency. For example, Tolley has shown that the average hourly wage for production workers in the meat packing industry was about 30 cents higher in the East North Central than in the South Atlantic states in 1947.[9] Yet Judge and Wallace in their discussion failed even to mention the importance of wage differentials.

The final comment concerns the assumptions and techniques utilized by Judge and Wallace in order to solve the spatial equilibrium model for 1963 (page 32 of their report). They estimated values of income, slaughter, and population for 1963 by assuming that the percentage change from 1955 to 1963 would be the same percentage change that occurred between 1947 and 1955. Then using income and slaughter (assuming that all slaughter will be consumed) in their demand function, they estimated the retail price of pork to be 70.5 cents per pound for 1963 in the base region (region 9). Their retail price estimate for 1955 for the same base region was 52.9 cents per pound. During the 1947 to 1955 period the average retail price of pork declined by approximately 6 cents per pound.[10] Now, if hog producers increased production by a certain per cent between 1947 and 1955 when the retail price dropped by about 6 cents per pound, *is it realistic to expect the same percentage increase in production by 1963 if the retail price goes up by 17 cents per pound?* Their assumptions regarding expected supply in 1963 seems inconsistent with their predicted retail price.

While this note has been limited to some aspects that are weaknesses in the recent work by Judge and Wallace, it does not mean that they have not done a commendable job in increasing the amount of knowledge available and illustrating the use of a technique to evaluate the marketing system in the livestock and meat industry. However, it also illustrates that elegant techniques of measurement will not substitute for getting dirty hands from the laborious task of data source creation. The purpose in pointing out these weaknesses is solely to encourage further research by illustrating the need for more intensive study of several aspects of our marketing system for livestock and meats, particularly the need for developing more adequate data for analysis.

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[8] *Pork Marketing Margins and Costs,* U.S. Dept. Agr., AMS Misc. Pub. No. 711, April 1956.

[9] George S. Tolley, "Labor Market Efficiency for Agricultural Processing," *J. Farm Econ.*, 39:702, Aug. 1957.

[10] *Livestock and Meat Statistics 1957,* Stat. Bul. No. 230, U.S. Dept. of Agr., AMS, July 1958, p. 172.

A REPLY TO: "A NOTE ON ANALYTICAL MODELS"

G. G. JUDGE AND T. D. WALLACE
University of Illinois and North Carolina State College

WE appreciate the editor of this *Journal*, in accordance with custom, making available to us for comment an advance copy of the preceding Note. However, in this instance we feel that a detailed counter argument about the issues raised by Stout would add very little to current professional knowledge. Therefore, we invite readers interested in this area of research to read the series of three reports,[1] of which the bulletin discussed by Stout is a member, and form their own judgment on the appropriateness of the restrictive and expository assumptions and data used to illustrate a method and to give a rough description of some important economic relationships in the livestock and meat economy.

After a quantitative study is completed one can always ask, "why did or didn't you include this variable, why did you use this set of stochastic assumptions, how could you have conceivably used this set of data, etc.?" Furthermore, as most everyone realizes, in the interdependent compromise between economic and statistical assumptions, manageability and realism, data and inference, there are many alternatives that confront the investigator[2] Some of the alternatives are infeasible because of the limits on the researcher's time and available funds. At the time of the study alluded to (the first six months of 1958), out of the set of admissible alternatives, we put together what were in our judgment the best compromises regarding model, method, and data.

In any event the ultimate worth of the research depends on the predictive accuracy of the results and its use in reflecting the consequences of alternative courses of action for planning purposes. If and when sufficient regional data become available, the accuracy of regional models in their predictive power can be assessed. Until that time arrives, "reasonableness" of assumptions and the use of scanty data provide only imperfect criteria for assessment. Certainly, the collection of regional data more in line with the theoretical variables specified in the models should increase the accuracy of the results of spatial research. However, data are not free and there remains the economic decision concerning the costs and returns involved in gathering them.

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[1] *Spatial Price Equilibrium Analysis of the Livestock Economy:*
1. "Methodological Development and Annual Spatial Analyses of the Beef Marketing Sector," Okla. Exp. Sta. Tech. Bul. TB-78, 1959.
2. "Application of Spatial Analysis to Quarterly Models and Particular Problems Within the Beef Marketing System," Okla, Exp. Sta. Tech. Bul. T-79, 1959.
3. "Spatial Price Equilibrium Models of the Pork Marketing System," Okla. Exp. Sta. Tech. Bul. T-81, 1960.

[2] For discussion of a set of alternatives facing the quantitative researcher see: E. J. R. Booth and G. G. Judge, "The Impact of the Choice of Model on Measurements of Economic Behavior Relations," *J. Farm Econ.*, 38:570-83, 1956.

SOME DIFFICULTIES WITH EMPIRICAL RESULTS FROM WHOLE-FARM COBB-DOUGLAS-TYPE PRODUCTION FUNCTIONS[1]

JOHN R. HILDEBRAND[2]
Kansas State University

IT HAS been common in the literature to estimate marginal value productivities for farm input categories based on only one year's data, one grouping of farms, one particular model or variant, and on this basis to draw conclusions concerning resource use. This study raises some serious questions concerning the reliability of such an approach. In fact, an important finding of this research has been the wide variability of results from year to year and from model to model. To the writer's knowledge there has not appeared in the literature any similar experiment concerning the Cobb-Douglas production function with respect to a sequence of years and a series of slight model variations.

Data were secured from Farm Management Association records[3] for the years 1950-52 for a number of farms in a southeastern Kansas area (Wilson, Neosho, Crawford, Montgomery, Labette, and Cherokee counties) and in a west-central Kansas area (Wallace, Logan, Greeley, Wichita, Scott, Hamilton, and Kearny counties)—generally considered to represent low and high income farm areas, respectively, for the state.

The Cobb-Douglas production function technique[4] was utilized in an attempt to estimate for the various input categories the marginal value productivities required in the theoretical framework. Expressed in logarithmic form the equation is

$$\log Y = \log \alpha + a \log X_1 + b \log X_2 + c \log X_3 + d \log X_4$$

The equation was fitted by the usual least squares procedure.

Identification of Variables

The independent and dependent variables reflect the technique of production in use in the respective periods as well as the prevailing prices of those years. Inventory accounts were valued at prevailing prices. Variables were classified in the following manner.

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[1] Contribution No. 319, Kansas Agricultural Experiment Station, Manhattan, Kansas. Research funds were provided by the Kansas Station.

[2] The author is indebted to T. W. Schultz, D. Gale Johnson, Zvi Griliches, and Carl Christ, as well as to his colleagues at the Kansas Station—especially Dale Knight, Walter Fisher, and the statisticians of the statistical laboratory—for helpful suggestions. However, responsibility for any errors or misjudgments is the author's.

[3] These records have been collected, summarized, and analyzed for a number of years under the supervision of Adair Hodges.

[4] Reasons for using this approach are summarized by Gerhard Tintner and O. H. Brownlee in their article, "Production Functions Derived From Farm Records," *J. Farm Econ.*, 26:567 (Aug. 1944).

Gross farm income (Y) includes the total output of the farm measured in dollars. Thus the ownership arrangements do not distort the results.

Labor input (X_1) was expressed in physical terms of months. It includes unpaid family labor, hired labor, and operator's labor.

The livestock input (X_2) covers essentially the whole of the livestock enterprise, i.e., it includes feed expenses, grass at rental costs, and a 6 percent interest charge on average inventory value of livestock for the year. It is thus entered as a flow, not as a stock concept.

The equipment and current expense category (X_3) is also a flow concept measured in dollars. This figure is obtained by allowing 15 percent of the beginning inventory and purchases of machinery to cover interest and depreciation charges. All current expense items not considered part of the livestock enterprise are included in this category.

The land input, X_4, is restricted to crop acres harvested, to secure greater homogeneity. Measured in acres, it is thus a stock concept.

Sequence of Models

The series of models as listed in the tables was developed in an experimental effort to help explain the variability in estimates encountered in the initial model. The nature of the various models should be clear from the notation given in the tables except for the heading, "Identical farms." Here the management factor was held "constant" by using only those farms that had the same operator throughout the three years. The effects of grouping by farm size (acres), substracting X_3 from Y (on the supposition that this was a rough approximation of the contribution of equipment and expenses and would prevent its imputation to other categories), deleting X_3 entirely, and pooling the three years' data were successively explored.

Correlation and Regression Coefficients

An examination of the simple coefficients of correlation indicated significant relationships of nearly all X's with their respective Y's at about the 1 percent level of probability.

The multiple correlation coefficients for all functions were significant at the 1 percent level except for the Y-X_3 model for 1952 for southeastern Kansas. The four-input models generally "explain" only a slightly larger percentage of the variation in the Y's than the model with X_3 eliminated from both sides of the equation.

The regression coefficients or elasticities (tables 1 and 2) show the percentage increase in output one can expect from a 1 percent increase in the respective inputs. The estimated marginal value product in each case equals $e\ \bar{Y}/\bar{X}$ where $\bar{Y}$ is the geometric mean of gross income, $\bar{X}$ is the geometric mean of the particular input, and e is the estimated elasticity for that input.

TABLE 1. SAMPLE SIZE, COEFFICIENTS OF MULTIPLE DETERMINATION, AND REGRESSION COEFFICIENTS (ELASTICITIES) FOR ALL MODELS FOR AREA I—SOUTHEASTERN KANSAS

Model and Year	Sample Size	Coefficient of Multiple Determination	Regression Coefficient for—			
			Labor	Livestock Enterprise	Equipment and Expenses	Crop Acres
	n	R^2	X_1	X_2	X_3	X_4
$Y=\alpha X_1^a X_2^b X_3^c X_4^d$						
All farms						
1950	44	.914	.2513[a]	.3133[a]	.2689[a]	.3732[a]
1951	34	.849	.2852[a]	.2590[a]	.4189[a]	.2162
1952	29	.815	.2820	.2606[a]	.8310[a]	.0295
<320 acres						
1950	11	.837	.6074	.3690	−.3409	.6206[a]
1951	11	.734	.3524	.0934	.7086[a]	−.0978
1952	8	.869	.5786	.4836	.6923	−.0084
>320 acres						
1950	33	.917	.1710	.2689[a]	.4135[a]	.2584[a]
1951	23	.773	.1750	.3480[a]	.1922	.3739[a]
1952	21	.809	.1672	.2608[a]	.8737[a]	.1885
"Identical farms"						
1950	22	.909	.2330	.2577[a]	.3249	.3488[a]
1951	22	.866	.0820	.3374[a]	.2958	.3161[a]
1952	22	.843	.4130	.2508[a]	.6867[a]	.0364[a]
$Y-X_3=\alpha X_1^a X_2^b X_4^d$						
All farms						
1950	44	.465	.6101	.5645	—	.9236[a]
1951	34	.730	.4595[a]	.4174[a]	—	.4107[a]
1952	29	.197	.3409	.8974	—	.7061
$Y=\alpha X_1^a X_2^b X_4^d$						
All farms						
1950	44	.901	.3305[a]	.3711[a]	—	.5121[a]
1951	34	.807	.3307[a]	.3654[a]	—	.4588[a]
1952	29	.630	.4702	.4578[a]	—	.5271[a]
All farms, 1950–52						
(LS[b])	107	.758	.3793[a]	.3644[a]	—	.4850[a]
(C[b])	107	.792	.3468[a]	.3904[a]	—	.4948[a]

[a] Significant at 5 percent level.
[b] LS stands for Least Squares unadjusted for yearly effects; C for Analysis of Covariance in which ordinary Least Squares procedure is adjusted for yearly effects.

The sum of the elasticities for any function indicates returns to scale, i.e., if accepted as greater than one, we have increasing returns; if less than one, decreasing returns; and if equal to one, we have constant returns to scale. If the sum of the elasticities is less than or equal to unity, then operation is in the relevant economic range; if greater than unity, then economies of scale should be exploited by expansion. The sum was greater than one in all cases in southeastern Kansas, but greater than one in only eight of the 17 cases in west-central Kansas.[5]

[5] A test of statistical significance of the evidence of increasing returns to scale was made where model $Y = \alpha X_1^a X_2^b X_3^c X_4^d$ was used for all farms. Following a porcedure used by Gerhard Tintner (*Econometrics*, pp. 89-91) to test the hypothesis that there is a linear homogeneous production function, it is found that the hypothesis is re-

TABLE 2. SAMPLE SIZE, COEFFICIENTS OF MULTIPLE DETERMINATION, AND REGRESSION COEFFICIENTS (ELASTICITIES) FOR ALL MODELS FOR AREA 12—WEST-CENTRAL KANSAS

Model and Year	Sample Size n	Coefficient of Multiple Determination R^2	Regression Coefficient for— Labor X_1	Livestock Enterprise X_2	Equipment and Expenses X_3	Crop Acres X_4
$Y=\alpha X_1^a X_2^b X_3^c X_4^d$						
All farms						
1950	46	.755	.1377	.1756[a]	.2574	.4097[a]
1951	52	.699	−.0778	.1583[a]	.7376[a]	.0914
1952	46	.788	.3021	−.1150[a]	.3408	.7072[a]
<1600 acres						
1950	22	.794	.1680	.3376[a]	.1754	.4189[a]
1951	27	.651	−.0984	.1279[a]	.9690[a]	.0103
1952	26	.829	.5023[a]	−.1175	.0490[a]	.9380[a]
>1600 acres						
1950	24	.646	−.0059	.1095[a]	.1794	.2782
1951	25	.783	−.2765	.2009[a]	.1466	.6726[a]
1952	20	.689	−.0451	−.0550	.6707	.6675[a]
$Y-X_3=\alpha X_1^a X_2^b X_4^d$						
All farms						
1950	46	.503	−.3900	.4725[a]	—	1.3323[a]
1951	52	.642	−.6780	.8008[a]	—	.3638[a]
1952	46	.583	.5671	−.2088	—	1.1112[a]
$Y=\alpha X_1^a X_2^b X_4^d$						
All farms						
1950	46	.737	.2533	.1853[a]	—	.4944[a]
1951	52	.575	.3862[a]	.1884[a]	—	.2464[a]
1952	46	.771	.4699[a]	−.1249[a]	—	.8836[a]
All farms, 1950–52						
(LS[b])	144	.5523	.3171[a]	.1331[a]	—	.4322[a]
(C[b])	144	.5529	.3550[a]	.1231[a]	—	.4180[a]

[a] Significant at 5% level.

[b] LS stands for Least Squares unadjusted for yearly effects; C for Analysis of Covariance in which ordinary Least Squares procedure is adjusted for yearly effects.

Marginal Productivities and Tests of Hypotheses

What information have we gathered concerning possible resource allocation problems in the two Kansas farm areas? How are we to utilize the estimated marginal productivities and sums of elasticities (tables 3 and 4) to test the following hypotheses frequently encountered in the literature?

1. The scale of the farm firm is too small.
2. Excess labor exists in the farm firm.
3. There is inadequate investment in the livestock enterprise by the farm firm.
4. The farm firm's expenditures on equipment and current service items are inadequate.

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jected for all three years in southeastern Kansas and for 1952 in west-central Kansas. However, for 1950 and 1951 in west-central Kansas the sums of elasticities (slightly below unity) were not significantly different from unity.

TABLE 3. SUM OF ELASTICITIES AND ESTIMATED MARGINAL VALUE PRODUCTIVITIES FOR ALL MODELS FOR AREA I—SOUTHEAST KANSAS

Model and Year	Sum of Elasticities	Marginal Value Productivity of—			
		Labor X_1	Livestock Enterprise X_2	Equipment and Expenses X_3	Crop Acres X_4
$Y=\alpha X_1^a X_2^b X_3^c X_4^d$		*Per Month*	*Per Dollar Input Flow*		*Per Acre*
All farms					
1950	1.2067	$156.83	$1.75	$0.87	$26.97
1951	1.1792	249.00	1.41	1.29	18.64
1952	1.4117	186.66	0.88	1.91	1.93
<320 acres					
1950	1.2561	304.41	1.86	−0.99	42.17
1951	1.0566	242.60	0.42	1.92	−7.50
1952	1.7461	338.50	1.30	1.55	−0.62
>320 acres					
1950	1.1118	115.11	1.55	1.40	19.09
1951	1.0891	156.66	1.89	0.57	31.20
1952	1.4902	115.96	0.96	1.99	11.80
"Identical farms"					
1950	1.1644	153.33	1.75	1.08	22.81
1951	1.0313	66.19	2.08	0.59	24.14
1952	1.3869	287.84	0.95	1.59	2.40
$Y-X_3=\alpha X_1^a X_2^b X_4^d$					
All farms					
1950	2.0982	223.36	1.84	—	39.14
1951	1.2876	237.68	1.34	—	20.98
1952	1.9444	93.01	1.25	—	19.03
$Y=\alpha X_1^a X_2^b X_4^d$					
All farms					
1950	1.2137	206.58	2.07	—	37.06
1951	1.1549	271.90	1.87	—	37.25
1952	1.4551	311.16	1.55	—	34.45
All farms, 1950–52					
(LS[a])	1.2287	285.03	1.87	—	38.42
(C[a])	1.2320	260.57	2.01	—	39.20

[a] LS stands for Least Squares unadjusted for yearly effects; C for Analysis of Covariance in which ordinary Least Squares procedure is adjusted for yearly effects.

5. Insufficient crop land resources are used per farm firm.

6. Malallocation of resources is general in Kansas agriculture but most severe in southeastern Kansas.

The unsatisfactory nature of the final results is clear. Stability in the productivity estimates or even stable patterns is lacking. The nature and extent of the fluctuations are alarming. In fact, viewing all estimates together, the results jump about irregularly almost as though the productivity pie were being carved by a sledge hammer. As given in tables 3 and 4, the range of estimates for a month of labor moved from −$409.40 to +$647.01; for the livestock input, from −$1.96 to +$5.61; for equipment and expenses, from −$.99 to +$3.13; and for crop acres, from −$7.50 to +$50.36.

Judging from the empirical results of this study, it appears that one

TABLE 4. SUM OF ELASTICITIES AND ESTIMATED MARGINAL VALUE PRODUCTIVITIES FOR ALL MODELS FOR AREA 12—WEST-CENTRAL KANSAS

Model and Year	Sum of Elasticities	Marginal Value Productivity of—			
		Labor X_1	Livestock Enterprise X_2	Equipment and Expenses X_3	Crop Acres X_4
$Y=\alpha X_1^a X_2^b X_3^c X_4^d$		*Per Month*	*Per Dollar Input Flow*		*Per Acre*
All farms					
1950	0.9803	$134.20	$2.80	$0.80	$17.20
1951	0.9095	− 83.03	1.96	2.37	4.07
1952	1.2351	416.04	−1.48	1.21	36.51
<1600 acres					
1950	1.0998	144.24	4.38	0.49	20.19
1951	1.0089	−101.70	1.59	3.13	0.53
1952	1.3718	640.07	−1.96	0.17	50.36
>1600 acres					
1950	0.5613	− 6.45	0.22	0.57	9.70
1951	0.7437	−305.55	2.47	0.70	25.74
1952	1.2380	− 68.72	−0.51	2.50	32.01
$Y-X_3=\alpha X_1^a X_2^b X_4^d$					
All farms					
1950	1.4148	−196.36	3.98	—	28.90
1951	0.4866	−409.40	5.61	—	9.16
1952	1.4695	508.72	−1.75	—	37.01
$Y=\alpha X_1^a X_2^b X_4^d$					
All farms					
1950	0.9330	246.87	3.02	—	20.76
1951	0.8210	412.22	2.33	—	10.96
1952	1.4784	647.01	−1.61	—	45.17
All farms, 1950–52					
(LS[a])	0.8824	356.61	1.82	—	19.73
(C[a])	0.8961	399.26	1.68	—	19.09

[a] LS stands for Least Squares unadjusted for yearly effects; C for Analysis of Covariance in which ordinary Least Squares procedure is adjusted for yearly effects.

can hit on or select a particular model or application of a model to "support" nearly any recommendation concerning resource use. Based on the experience of this study, one might raise a question whether other functions of the type developed here, if similarly extended over a period of years and groups, would yield results so variable and disconcerting as to defy adequate rationalization. One might suspect that throughout the academic world there are many functions with "unusable" results filed quietly away. Candidly, in the interest of the progress of the profession such difficulties should be kept in the open for scrutiny by all researchers. "Unusable" results filed quietly away where they are "out of sight, out of mind" can contribute little to the advancement of the science. Following this point of view, all estimated marginal value productivities have been reported even though seriously conflicting or contradictory. The apparent productivity relationships derived statistically must, in many cases, be deviating substantially from the actual relationships.

One way around the divergent results of the 37 production functions would be the selection of a particular function to meet ones "needs." However, the impropriety is quite clear from the data presented. Nevertheless, assuming one is permitted to select on an *ex post* basis, the last function listed for each area seems most reasonable. Here the data are pooled over the three year period, giving a single set of regression coefficients which could be considered to represent the elements common to all of the years. One can only raise a question as to whether the results would all appear "reasonable" if these functions could have been run over a number of three-year periods.

Utilizing the covariance technique,[6] a refinement has been made by sifting out a source of variation with a yearly effects factor, i.e., yearly differences due to such factors as differential weather, pests, diseases, and prices over time. The hypothesis that there is no yearly effect upon gross income in any of the three years is rejected at $P < .001$ and $P \cong .10$ for southeast and west-central Kansas, respectively.

In the interest of brevity, we leave the reader to take it upon himself to check the hypotheses against any or all of the marginal productivities as his judgment may dictate.

An Appraisal[7]

It would be desirable if some explanation could be tendered regarding the wide variability of results from year to year and from model to model. The complexity of the problem forestalls a definitive answer. It may well be that a concatenation of many rather small items may be flipping the elasticities and marginal productivities about. However, a brief discussion of some individual factors contributing to the difficulty follow.

Year to year variations in statistical estimates reflect in part fluctuations in prices and yields. Yet, upon inspection it is the writer's judgment that only the negative elasticity and marginal productivity for the livestock input (X_2) for 1952 in west-central Kansas is readily explainable in this manner—specifically, the precipitous price break for beef cattle shows up clearly for this western region. Averaging techniques and the

[6] For a discussion of the technique see Irving Hoch, "Estimation of Agricultural Resource Productivities Combining Time Series and Cross Section Data" (unpub. Ph.D. diss., Univ. of Chicago, 1957).

[7] An excellent series of articles grappling with Cobb-Douglas problems may be found in a volume edited by Earl O. Heady, Glenn L. Johnson, and Lowell S. Hardin, *Resource Productivity, Returns to Scale, and Farm Size* (Iowa State Univ. Press, 1956).

See also Zvi Griliches, "Specification Bias in Estimates of Production Functions," *J. Farm Econ.*, 39:8-9, Feb. 1957, and James S. Plaxico, "Problems of Factor-Product Aggregation in Cobb-Douglas Value Productivity Analysis," *J. Farm Econ.*, 37:672, Nov. 1955.

development of physical production functions may be helpful here. The functions pooling the data for the three-year period provide one type of averaging.

The variations in statistical estimates over years and models indicate that elasticities and marginal productivities are easily flipped about by modest changes in farm groupings or in the treatment of inputs. It would be interesting to compare the results of algebraic forms other than the Cobb-Douglas. Insights on the difficulties might be revealed by a series of years with a large sample size or by a more carefully selected group of farms. Perhaps the complexities that apparently result in a capricious shifting about of productivities will have to be met by using specialized farms (single enterprise) and reducing (deleting or consolidating) the number of inputs to minimize distorting intercorrelation problems. Additional experimentation is needed with respect to input omission and input grouping procedures to understand the effects and facilitate appropriate interpretation of the results.

A further difficulty occurs if inputs and outputs are deliberately distorted (either for tax evasion or avoidance) or if measurements do not correspond to the respective accounting periods under study. Since these hazards are present in this work, closer supervision and prescribed accounting procedures will be required to provide more accurate basic data.

Concluding Remarks

The extreme variability and irregularity of the estimates of elasticities and marginal productivities over the three years and various stratifications make it appear that productivity is being picked up in a capricious fashion without even following any simple pattern of bias.

Some possible refinements have been suggested. The stage of development represented by the empirical results of this study indicates that many hurdles have not yet been cleared, and that Cobb-Douglas results of this nature must be used with caution. Corroborating evidence and judgment is still important despite the desire to get away from the weaknesses and subjectivity inherent in human judgment.

Many difficulties remain to be resolved in this area of production economics. As often happens in research, questions are abundant—answers inadequate and scarce. It is hoped that a bit of new kindling has been added to the fire of progress.

CONSEQUENCES OF ACREAGE ADJUSTMENTS ON CORN-BELT FARMS[1]

J. E. FRUIN, C. B. BAKER, AND V. I. WEST
University of Illinois

IN THIS paper we compare in 1951 and 1957 actual and optimum incomes for farms that increased acreage and those that did not. Actual incomes were reported by 185 farmers in east-central Illinois (a cash-grain area). Optimum incomes were generated by a linear programming model that allocated resources typical of these farms among alternatives available to the operators.

The Farms

Basic data were taken from accounts of farmers cooperating with the University of Illinois in 1951 and 1957 from east-central Illinois.[2] The years 1951 and 1957 were selected because of similarity in weather and working conditions. Also, the time span allowed completion of major adjustments.

We define as "constant-acreage farms" (106) those with an acreage increase between 1951 and 1957 of not more than 20 acres. "Increased-acreage farms" (79) are those reporting an increase of more than 20 acres. Each class of farms was further divided into one-, one-and-one-half-, two-, and three-or-more-man farms, according to the 1951 labor supply. The average months of available labor were, respectively, 13.3, 17.8, 23.6, and 37.5. Average land and labor supplies for farms in each category are summarized for 1951 and 1957 in Table 1.

Annual labor supply was obtained by multiplying by 250 (hours per month for a man equivalent) the average months for each size category.[3] For the one-, two-, and three-or-more-man farms, labor was assumed to be distributed equally among the quarters indicated. For the one-and-one-half-man farms (group 2) the peak labor requirements from May through October were assumed met with either seasonally hired labor or added family labor. The month groupings are based on similarity and transferability of crop labor requirements.

We note that the labor supply dropped slightly between 1951 and 1957 for all farms except for an increase of 81 man hours per quarter for

[1] Based on *Efficiency of Production on Central Illinois Farms As Measured by Differences Between Actual Income and Linear Programming Optima 1951-1957*, unpublished M.S. thesis submitted in 1959 by J. E. Fruin to the Department of Agricultural Economics, University of Illinois.

[2] The counties are Champaign, Douglas, DeWitt, Macon, Moultrie, Piatt, and Vermilion.

[3] *Detailed Cost Report for Northern Illinois, 1956*, Ill. Agr. Exp. Sta. AERR-21, 1958. Although individuals are found occasionally to work more than 250 hours per month, the maximum in any three-month period was from 750 to 800 hours.

TABLE 1. RESOURCES AVAILABLE ON CONSTANT ACREAGE AND INCREASED ACREAGE FARMS, BY LABOR SIZE OF FARM: EAST-CENTRAL ILLINOIS, 1951 AND 1957[a]

Item	Constant-acreage farms: labor group—				Increased-acreage farms: labor group—			
	1	2	3	4	1	2	3	4
Number of farms	37	36	20	13	22	17	23	17
Resources in 1951:								
Land (acres)	210	252	326	593	187	293	363	504
Labor (hours)								
February–April	831	992	1,475	2,344	838	992	1,456	2,341
May–July	831	1,233	1,475	2,344	838	1,233	1,456	2,341
August–October	831	1,233	1,475	2,344	838	1,233	1,456	2,341
November–January	831	992	1,475	2,344	838	992	1,456	2,341
Resources in 1957:								
Land (acres)	209	252	328	589	242	385	459	644
Labor (hours)								
February–April	806	883	1,362	2,012	825	987	1,537	2,119
May–July	806	1,017	1,362	2,012	825	1,224	1,537	2,119
August–October	806	1,017	1,362	2,012	825	1,224	1,537	2,119
November–January	806	883	1,362	2,012	825	987	1,537	2,119

[a] Source: Adapted from summary sheets of Farm Bureau Farm Management Service record keepers, 1951 and 1957.

the two-man farms that increased acreage. The increase in acreage for the "increased-acreage farms" exceeded substantially the average increase for all Illinois farms in this time period.

Actual Incomes in 1951 and 1957

Farms in each group reported returns to land, capital, and all labor as shown, for 1951 and 1957, in Table 2. Numbers in parentheses are standard errors of income with respect to the arithmetic means. Between constant-acreage and increased-acreage farms, the income differences in 1951 are not significant at acceptable probability levels for any labor-size group.

TABLE 2. ACTUAL INCOME, BY LAND AND LABOR-SIZE GROUPS: EAST-CENTRAL ILLINOIS, 1951 AND 1957[a]

Labor Group (Man Equivalents)	Constant-Acreage Farms		Increased-Acreage Farms	
	1951	1957	1951	1957
One	$10,874 ($590)	$ 7,284 ($584)	$ 9,964 ($772)	$ 8,800 ($915)
One and one-half	13,590 (724)	8,407 (583)	14,595 (1,809)	13,349 (1,632)
Two	18,062 (1,218)	12,603 (1,103)	20,823 (1,487)	15,624 (1,370)
Three or more	27,746 (3,345)	20,896 (3,259)	33,573 (3,416)	25,805 (3,034)

[a] Source: Summary sheets from accounts of Farm Bureau Farm Management Service record keepers, 1951 and 1957. Figures in parentheses are estimates of standard errors of means shown immediately above.

Nor are the differences significant in 1957, except for the one-and-one-half- and possibly the two-man size groups.[4] Between 1951 and 1957 the income reductions were significant for all labor-size groups in the constant-acreage class of farms. For the increased-acreage farms, however, the reductions were significant only for the two- and three-or-more-man farms.

These results are particularly interesting since they cast some doubt on the pay-off from increasing land size for farms with a labor supply of two or more men. Note also that the increased-acreage farms exhibit a consistently higher income variation than do the constant-acreage farms. The single exception is the largest labor size farms in 1957.

Optimum Incomes in 1951 and 1957[5]

We turn next to incomes produced by farms optimally organized in each class. Alternatives for the use of resources consisted of four cattle-feeding systems, three hog systems, crops common to the area and the sale of corn. Products were priced at 1950 and 1956 levels for the 1951 and 1957 solutions, respectively, reflecting the assumed use of a simple or "naive" expectation model. For example, corn was priced at $1.51 and $1.35 per bushel for the 1951 and 1957 models, respectively. Except for wheat, little change occurred between 1951 and 1957 in net returns per acre. An increase from wheat was created by a nearly 50 percent increase in yield. However, a restriction was imposed by the government program and by the relation of small grain to hay and pasture.

Returns per animal dropped substantially between 1951 and 1957 for yearlings and two-year-old cattle. For calves, the reduction in sales price was so offset by reductions in purchase price and nonfeed costs that the net change in returns was small. Per litter returns for hogs declined sharply between 1951 and 1957.

Besides restrictions imposed by land and labor supplies, inventories of corn, pasture, and hay were postulated to remain unchanged from a one-year operation. The combined acres in pasture and hay were required not to exceed the acres in small grain (wheat and/or oats). In 1957 a government allotment of 15 acres was assumed for wheat.

Incomes generated by optimum farm plans are shown for all farms in Table 3. For constant-acreage farms, the optimum income in 1957 is but slightly less than in 1951 for all labor sizes. Were variability estimates available, the differences surely would be nonsignificant. By contrast, we recall that actual declines for constant-acreage farms were significant for all labor sizes.

[4] For the two-man farms, the probability of a chance difference as large as shown is less than ten percent but greater than five percent.

[5] For details on structure of the programming model and on estimates of technical coefficients, see J. E. Fruin, *Efficiency of production . . ., op. cit.*

TABLE 3. OPTIMUM INCOME, BY LAND AND LABOR-SIZE GROUPS: EAST-CENTRAL ILLINOIS, 1951 AND 1957[a]

Labor Group (Man Equivalents)	Constant-Acreage Farms		Increased-Acreage Farms	
	1951	1957	1951	1957
One	$12,961	$12,827	$11,817	$14,779
One and one-half	16,082	15,373	18,290	23,277
Two	20,640	19,923	22,459	27,686
Three or more	36,591	35,424	32,025	38,687

[a] Source: J. E. Fruin, *Efficiency of Production on Central Illinois Farms . . . , op. cit.*

For increased-acreage farms, the optimum income increased in 1957 over 1951 for all labor sizes. Though no estimates are available on likely variation, the increases are substantial. From Table 2 we recall that for one- and for one-and-one-half-man farms there was between 1951 and 1957 a slight (nonsignificant) decline in actual income. For the two- and the three-or-more-man farms the income reductions were significant.

Differences Between Actual and Optimum Incomes

In Table 4 we show for all farms the difference between optimum and actual incomes. Optimum incomes are based on previous year prices. Hence, a negative difference is possible, as shown for three-or-more-man farms in the increased acreage group for 1951. However, this negative number and the relatively small difference for the two-man farms indicate that larger farms were operated close to optimum in 1951 by those who subsequently increased acreage.

Figures in parentheses in Table 4 are estimates of standard errors of

TABLE 4. OPTIMUM INCOME MINUS ACTUAL INCOME, BY LAND AND LABOR SIZE OF FARM: EAST-CENTRAL ILLINOIS, 1951 AND 1957[a]

Labor Group (Man Equivalents)	Constant-Acreage Farms		Increased-Acreage Farms	
	1951	1957	1951	1957
One	$2,087 ($834) ($590)	$5,543 ($775) ($548)	$1,853 ($1,092) ($772)	$5,979 ($1,294) ($915)
One and one-half	2,492 (1,024) (724)	6,966 (824) (583)	3,695 (2,558) (1,809)	9,928 (2,308) (1,632)
Two	2,578 (1,723) (1,218)	7,320 (1,598) (1,130)	1,636 (2,103) (1,487)	12,062 (1,937) (1,370)
Three or more	8,845 (4,731) (3,345)	14,528 (4,609) (3,259)	−1,548 (4,831) (3,416)	12,882 (4,270) (3,034)

[a] Source: J. E. Fruin, *Efficiency of Production on Central Illinois Farms . . . , op. cit.*

differences between optimum and actual incomes. The top figures are based on an assumption that the standard error of mean optimum income equals the standard error of mean actual income. The second figure is based on a standard error of mean optimum income assumed equal to zero. Thus it is assumed that the two figures bracket the range of values for the standard error of differences within which the "true" value might be found.

Under the first assumption regarding the standard errors, the difference between optimum and actual income is significant for the constant-acreage farms in 1951 only in the case of the one- and the one-and-one-half man farms; and for the increased-acreage farms, only for the one-man farms. For 1957 all differences are significant.

Under the second assumption regarding the standard errors, for the constant-acreage farms in 1951 all differences between optimum and actual incomes are significant. For increased-acreage farms the difference is significant only for the one-man and the one-and-one-half man farms. For 1957 all differences are, of course, significant.

To extend these estimates to change over time in differences between optimum and actual incomes is rather complex in the case of the first assumption. In addition to assuming that actual and optimum incomes have equal standard errors of means, one must assume that correlations among optimum incomes equal corresponding correlations among actual incomes for the years compared. The difference in change is not significant for one- and for one-and-one-half man farms. For two-man farms, the difference in change is significant only if the standard error of mean optimum income is assumed to be zero. For three-or-more-man farms, the difference in change is significant for either estimate of standard error.

Conclusions

Actual incomes dropped between 1951 and 1957 for farms that increased acreage and for those that did not. However, the decline was less for increased-acreage farms and significant only for two- and three-or-more-man farms.

Optimum incomes differed little in 1951 between constant-acreage and increased-acreage farms. By 1957 optimum incomes had increased for all increased-acreage farms and had decreased for all constant-acreage farms.

Actual incomes tended to diverge from optimum incomes in 1951 more consistently for constant-acreage farms than for increased-acreage farms. By 1957 both groups exhibited significant divergences. The divergences increased more for increased-acreage farms than for constant-acreage farms. However, the differences in divergence were significant only for the larger labor-size groups.

TOLERANCE INTERVAL FOR MULTIPLE REGRESSION[1]

JOHN Y. LU
Tidewater Oil Company

LEAST squares regression analysis is a familiar statistical technique to many agricultural economists. It is commonly used to estimate demand and supply relations in price analysis, and is also used to estimate production functions in farm management analysis. In many cases, statistical constants associated with a regression function are estimated from a single sample. Various statistical tests can then be constructed in order to provide some indications as to the frequency with which estimates of the statistical constants may vary in successive samples of the same size. The results of these tests will provide the economist a basis for judging the plausibility of approximating the underlying economic relation by some regression function. However, the ultimate usefulness of the estimated regression function rests on its accuracy in predicting the most probable value of the dependent variable for the new or future cases, i.e., to take new observations on the same set of the independent variables and to predict the value which the dependent variable is most likely to take based on these new observations.

Since the usefulness of a prediction depends on the magnitude of its possible error, it is important to consider some statistical measurements of this error. The investigation of this problem seems to have a rather long history. Various researchers have discussed the method of constructing the standard error of forecast and have indicated the use of the standard error for presenting forecast results from a regression function.[2]

Professor Wallis has proposed an alternative method of presenting the forecast results, which he calls tolerance intervals.[3] A tolerance interval defines a range within which a certain prespecified proportion of nonsample observations will be included with a desired probability level. The purpose of this paper is to extend the result obtained by Professor Wallis to multiple regression analysis, and to discuss some relative merits of the usual confidence interval and tolerance interval.

In order to bring the topic into focus, first a regression model is specified and some of the well known statistical properties of the model are noted.

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[1] The author has benefited from many valuable suggestions by the referees.

[2] Some of the important references in this field are: H. Working and H. Hotelling, "Application of the Theory of Error to the Interpretation of Trends," *J. Amer. Stat. Assoc.*, Vol. 24, 1929, Proceeding Supplement, pp. 73–85: H. Hotelling, "Problem of Prediction," *Amer. J. Soc.*, Vol. 48, July, 1942, pp. 61–76: M. Ezekiel, *Method of Correlation Analysis*, Second ed., New York, John Wiley and Sons, 1945, pp. 315–17, 341–58.

[3] W. A. Wallis, "Tolerance Interval for Linear Regression," *Second Berkeley Symposium on Mathematical Statistics and Probability*, J. Neyman, ed., Berkeley and Los Angeles; Univ. of Calif. Press, 1951.

This is followed by a brief review of the standard error of forecast. This background is then used to construct tolerance intervals for multiple regression, and the relationship between the tolerance interval and the standard error of forecast is indicated. An illustration is provided by calculating a tolerance interval for a predicted world wheat price based on the demand relation estimated by Meinken.[4] In the last section, some use and limitations of the tolerance interval and confidence interval are discussed. The appendix contains a note on scaling which has been found to be useful for calculating the standard error of forecast as well as the tolerance interval.

Regression Model

Consider the equations,[5]

$$y_n = \beta_1 z_{n1} + \beta_2 z_{n2} + \cdots + \beta_k z_{nK} + u_n, \qquad n = 1, 2, \cdots, N. \tag{1}$$

where y_n is the nth observation on a dependent variable whose mean, μ, is an unknown linear function of K observable non-random variables $z_{n1}, z_{n2}, \cdots z_{nK}$, usually referred to as independent variables. The β's are unknown coefficients of this linear function. The u's are unobserved disturbances which are assumed to be normally and independently distributed with zero means and the common variance σ^2.

If there are N sets (where $N > K$) of observations on the dependent variable as well as on the corresponding independent variables, maximum likelihood estimates of the unknown coefficients and variance can be derived. It is convenient at this point to adopt matrix notation for further discussion. Let

$$y = \begin{pmatrix} y_1 \\ y_2 \\ \cdot \\ \cdot \\ y_N \end{pmatrix} \quad u = \begin{pmatrix} u_1 \\ u_2 \\ \cdot \\ \cdot \\ u_N \end{pmatrix} \quad \beta = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \cdot \\ \cdot \\ \beta_K \end{pmatrix} \quad Z = \begin{pmatrix} z_{11} & z_{12} & \cdots & z_{1K} \\ z_{21} & z_{22} & \cdots & z_{2K} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ z_{N1} & z_{N2} & \cdots & z_{NK} \end{pmatrix}.$$

$$y = Z\beta + u \tag{2}$$

is an alternative way of stating equations (1). The maximum likelihood estimates of β, denoted by $\hat{\beta}$ are given by

$$\hat{\beta} = (Z'Z)^{-1}Z'y. \tag{3}$$

The estimate of variance σ^2, which has been corrected for small sample bias and is frequently denoted by s^2, is given by

$$s^2 = \frac{(y - Z\hat{\beta})'(y - Z\hat{\beta})}{N - K}. \tag{4}$$

[4] K. W. Meinken, *The Demand and Price Structure for Wheat*, Tech. Bul. No. 1136, U. S. Dept. Agr., Washington, D. C. The demand relation referred to here is equation 8 in p. 41.

[5] As is usual, a constant term is introduced by allowing z_{n1} to take the value of 1 for all n's.

It is well known that the maximum likelihood estimates of the coefficients have a multivariate normal distribution with mean vector β and covariance matrix $\sigma^2(Z'Z)^{-1}$, and $(N-K)s^2/\sigma^2$ has the chi-square distribution with $N-K$ degrees of freedom.

Standard Error of Forecast

The problem of deriving the standard error of forecast has been discussed by various authors since the appearance of a now classical paper on this subject by Working and Hotelling. The main results obtained by these authors are summarized here.

After obtaining estimates of the coefficients $\hat{\beta}$'s, the predicted value of the dependent variable $\hat{y}_F$ corresponding to a given set of non-sample observations on the independent variables, say $z_{F1}, z_{F2}, \cdots, z_{FK}$, is given by[6]

$$\hat{y}_F = \hat{\beta}_1 z_{F1} + \hat{\beta}_2 z_{F2} + \cdots + \hat{\beta}_K z_{FK}. \tag{5}$$

Since $\hat{y}_F$ is a function of the random variables $\hat{\beta}$'s, it has a probability distribution. Its mean is the true value of y_F and its variance is given by

$$\sigma_{\hat{y}_F}^2 = \sigma^2(z_{F1}z_{F2} \cdots z_{FK})(Z'Z)^{-1}(z_{F1}z_{F2} \cdots z_{FK})'. \tag{6}$$

The positive square root of (6) is called the standard error of regression function. This standard error can be used to construct a confidence band for the true regression function.

The standard error of regression function provides a convenient step for formulating what Ezekiel calls the standard error of an individual forecast. The latter is the standard error of the difference between a new observation y_F and the calculated value $\hat{y}_F$. Let $\Delta y_F = \hat{y}_F - y_F$. The expected value of Δy_F is zero. The variance of Δy_F is given by adding σ^2 to the variance of regression function:[7]

$$\sigma_{\Delta y_F}^2 = \sigma^2[1 + (z_{F1}z_{F2} \cdots z_{FK})(Z'Z)^{-1}(z_{F1}z_{F2} \cdots z_{FK})']. \tag{7}$$

If y_F is assumed to be normally distributed, Δy_F also has a normal distribution. Since the mean and variance of Δy_F are known, its probability distribution is completely specified. This knowledge about the distribution of Δy_F and the fact that $(N-K)s^2/\sigma^2$ is independently distributed of Δy_F with the chi-square distribution with $N-K$ degrees of freedom can be used

[6] H. Hotelling, *op. cit.*, pp. 65–68. He showed that this prediction formula has the following desirable statistical properties for every possible set of values which the independent variables may take:

(a) $\hat{y}_F$ is a linear combination of observed values y_n, for $n=1, 2, \cdots, N$.
(b) $\hat{y}_F$ is an unbiased estimate of y_F.
(c) The standard error of this prediction formula is as small as possible.

[7] A lucid discussion of the derivation of the standard error of Δy_F can be found in A. M. Mood, *Introduction to the Theory of Statistics*, McGraw-Hill Book Co., Inc., New York, 1950, pp. 297–99, 304–05.

for presenting the forecast results from (5). The usual procedure is to construct a statistic which has the t distribution with $N-K$ degrees of freedom as follows:

$$t = \frac{\dfrac{\Delta y_F}{\sigma_{\Delta y_F}}}{\dfrac{s}{\sigma}}. \tag{8}$$

From (8) and a table of the t distribution, one can construct an interval of the form $\hat{y}_F \pm t_\alpha s_{\Delta y_F}$ with a specified confidence coefficient, where $s_{\Delta y_F}$ is obtained by inserting s^2 in place of σ^2 in (7) and t_α is that number which the t statistic has a certain probability, say α, of exceeding.

Tolerance Interval

Professor Wallis has proposed an alternative procedure for presenting the forecast results from regression functions. His procedure is to construct an interval of the form $\hat{y}_F \pm \lambda s$, where λ is some positive constant, which has a certain probability of including at least a specified proportion of the population of y_F. Note that such a forecast statement contains two probability elements, viz., first, the probability that the stated interval includes the true value of y_F, and, second, the probability that the interval contains at least a specified proportion of the population of y_F. This scheme has an intuitive appeal because our interest is in predicting a future drawing from the population of the random variable y_F, not in some constant of the population.

In the remainder of this section, the derivation of tolerance intervals is discussed from a heuristic point of view. For a more rigorous derivation, see the paper by Professor Wallis.[8]

For any positive λ, let $A(\hat{y}_F, s, \lambda)$ or more briefly A, denote the proportion of the normal universe contained between the limits $\hat{y}_F \pm \lambda s$. A is clearly a random variable because these limits are functions of the random variables $\hat{y}_F$ and s.[9] The problem is to select the value of λ in the light of the sampling distribution of s so that the probability that A is at least as large as a

[8] W. A. Wallis, *op. cit.* Wallis' tolerance interval method is based on the work of Wald and Wolfowitz (A. Wald and J. Wolfowitz, "Tolerance Limits for a Normal Distribution," Ann. Math. Stat., Vol. 17, 1946, pp. 208–15). Wald and Wolfowitz considered the problem of deriving tolerance limits for a simple normal population, i.e., the situation analogous to (1) but β_2 to β_K are known to be zero. Wallis has extended their results to the case where the normal variate y_n has the mean $\beta_1 z_{n1} + \beta_2 z_{n2} + u_n$.

[9] In symbols

$$A = A(\hat{y}_F, s, \lambda) = \frac{1}{\sqrt{2\pi}} \int_{\hat{y}_F - \lambda s}^{\hat{y}_F + \lambda s} e^{-1/2\sigma^2 (t-\mu)^2} dt.$$

Since the limits of integration $\hat{y}_F \pm \lambda s$ are random variables, A must be a random variable.

prespecified value P is equal to another prespecified value γ. Let $\Pr(A \geq P) = \gamma$ denote this probability.

In order to determine λ, it is necessary to know how to evaluate $\Pr(A \geq P) = \gamma$. It has been shown by Wallis that $\Pr(A \geq P)$ can be approximated[10] by the conditional probability that A exceeds P for a particular value of $1/\sqrt{N'}$, that is,

$$\Pr(A \geq P) \simeq \Pr\left(A \geq P \mid \frac{1}{\sqrt{N'}}\right),$$

where the square of $1/\sqrt{N'}$ is

$$\frac{1}{N'} = (z_{F1}z_{F2} \cdots z_{FK})(Z'Z)^{-1}(z_{F1}z_{F2} \cdots z_{FK})'. \tag{9}$$

Note that N' is that factor which gives the variance of the statistic ϑ_F as in (6), when it is divided into the variance of an observation on the dependent variable y.

The probability

$$\Pr\left(A \geq P \mid \frac{1}{\sqrt{N'}}\right)$$

can be evaluated by noting that[11]

$$\Pr\left(A \geq P \mid \frac{1}{\sqrt{N'}}\right) = \Pr\left(s \geq \frac{r}{\lambda}\right) \tag{10}$$

where r is the half length of the interval centered at $1/\sqrt{N'}$ and the shaded area under the unit normal distribution has probability P as in Fig. 1. This factor r can be readily found from a table of the normal distribution because the shaded area is a strictly increasing function of r.

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[10] For a proof of the validity of this approximation, see Wallis, *op. cit.*, pp. 45–46. The difference

$$\Pr(A \geq P) - \Pr\left(A \geq P \mid \frac{1}{\sqrt{N'}}\right)$$

is of the order $(1/N')^2$.

[11] A sketch of this proof is as follows: Since $A(\vartheta_F, s, \lambda)$ as defined in footnote 9 is a strictly increasing function of s, we obtain exactly one root in s if we solve $A(\vartheta_F, s, \lambda) = P$ for s. Denote this root by $s = r(\vartheta_F, P, \lambda)$. Since $r(\vartheta_F, P, \lambda)$ has the factor $1/\lambda$, $\lambda r(\vartheta_F, P, \lambda)$ does not depend on λ. Hence we can write

$$\lambda r(\vartheta_F, P, \lambda) = r(\vartheta_F, P).$$

Since $A(\vartheta_F, s, \lambda)$ is a strictly increasing function of s, the inequality $A(\vartheta_F, s, \lambda) \geq P$ is equivalent to the inequality $s \geq r(\vartheta_F, P, \lambda) = r(\vartheta_F, P)/\lambda$. Therefore the probability of A exceeding P for any given value of ϑ_F is equal to $\Pr(s \geq r/\lambda)$. In particular, if we set $\vartheta_F = 1/\sqrt{N'}$,

$$\Pr\left(A \geq P \mid \frac{1}{\sqrt{N'}}\right) = \Pr\left(s \geq \frac{r}{\lambda}\right).$$

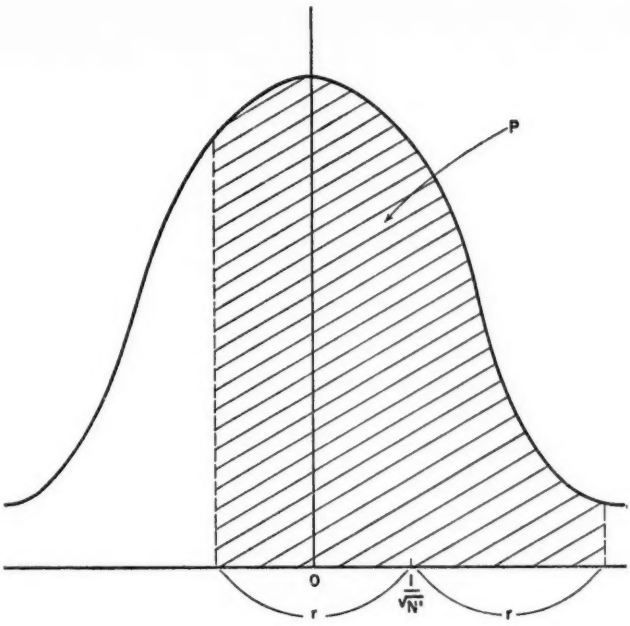


FIG. 1. DETERMINATION OF r.

Since

$$\frac{(N-K)s^2}{\sigma^2} = \chi^2(N-K)$$

has the chi-square distribution with $N-K$ degrees of freedom the right hand side of (10) can be equated to

$$\Pr\left[\chi^2(N-K) \geq \frac{(N-K)r^2}{\lambda^2}\right] \tag{11}$$

if $\sigma=1$.[12] For a given λ the probability (11) can be found in a table of the chi-square distribution.

The appropriate λ for

$$\Pr\left[\chi^2(N-K) \geq \frac{(N-K)r^2}{\lambda^2}\right] = \gamma$$

can be determined as follows: Find that number which the chi-square variate $\chi^2(N-K)$ has probability γ of exceeding from a table of the chi-square

[12] There is no loss of generality for standardizing the normal variate.

distribution. Let us denote this constant by $\chi_\gamma^2(N-K)$. Then solve the following equation for λ:

$$\chi_\gamma^2(N-K) = \frac{(N-K)r^2}{\lambda^2};$$

the result is

$$\lambda = r\sqrt{\frac{N-K}{\chi_\gamma^2(N-K)}}. \tag{12}$$

From (4), (5) and (12), an interval $\hat{y}_F \pm \lambda s$ can be obtained. This is an approximate tolerance interval which includes a specified proportion P of future observations on the dependent variable for the Fth period with a given confidence coefficient γ. In summary, a tolerance interval can be derived in three simple steps:

(a) Calculate the factor $1/\sqrt{N'}$;
(b) Determine the value of r from a table of the normal distribution;
(c) Solve for λ in (12) by using a table of the chi-square distribution.

Numerical Illustration

One of the structural equations in Meinken's econometric study of the wheat industry represents the demand relation. Coefficients and the standard error of estimate of this equation were estimated from a sample period of 15 years. The estimated equation is as follows:[13]

$$p_w = 142 - 0.036S_w + 1.1I_w, \qquad s = 7.54$$

where

P_W is the average wholesale price of wheat at Liverpool, England, per bushel, converted to United States currency at par, cents;
S_W is the domestic production plus stocks on July 1 of wheat minus use for seed and industrial purposes, million bushels;
I_W is an index of wholesale prices of 45 raw materials in England (1910 $-14=100$).

If observations on the independent variables are available in advance for the Fth period, say $S_w = 4000$ million bushels and $I_W = 110$ per cent, the predicted price based on the estimated equation is \$1.19. In terms of the notations developed in the previous sections:

$$\hat{y}_F = 119, \qquad z_{F1} = 1, \qquad z_{F2} = 4000, \qquad z_{F3} = 110.$$

Suppose one wishes to construct a tolerance interval such that it will

[13] Since Meinken used the least squares method for estimating the parameters of this equation, the tolerance interval method developed in the preceding section applies.

cover 90 per cent of the future observations on wheat price for the Fth period with probability 0.95. Here $P=0.90$ and $\gamma=0.95$. The first step is to calculate the factor $1/\sqrt{N'}$. The square of this factor can be obtained by premultiplying and postmultiplying the inverse of the sample moment matrix, i.e., $(Z'Z)^{-1}$, by a vector and its transpose whose elements consist of the new observations on the independent variables for which the forecast is made.[14]

$$\frac{1}{N'} = (1\ 4000\ 110)\begin{pmatrix} 15 & 69150 & 1838 \\ 69150 & 321083032 & 8357418.4 \\ 1838 & 8357418.4 & 233791.28 \end{pmatrix}^{-1}(1\ 4000\ 110)'$$

$$= 0.906766$$

For $1/\sqrt{N'}=0.952243$ and $P=0.90$, r is 2.24. For $\gamma=0.95$, $\chi_\gamma^2(N-K)$ is 21.0. Inserting these values into (12), the value of the toleranc factor can be obtained:

$$\lambda = 2.24\sqrt{\frac{12}{21.0}} = 1.693.$$

Hence, the desired tolerance limits are

$$131.765 = 119 + (1.693)(7.54),$$
$$106.235 = 119 - (1.693)(7.54).$$

Conclusions

The main difference between the confidence interval based on the standard error of an individual forecast and the tolerance interval developed here lies in the interpretation of their respective confidence coefficients. Suppose the confidence coefficient associated with a confidence interval is 95 per cent. This coefficient applies to the whole process of drawing a sample of N sets of observations on the dependent and independent variables of a regression function, calculating the interval and drawing another set of observations. If this entire process is repeated, 95 per cent of the times the interval will include the new observation on the dependent variable. On the other hand, if the same interval is to be applied to a number of new observations on the dependent variable for a particular period, the proportion of the times that these observations lie within the interval becomes a random variable. For this case, the tolerance interval method offers a more suitable way of presenting the forecast results. The confidence coefficient associated with a tolerance interval should be referred to the process of

[14] In carrying out this calculation, it is generally advisable to scale each element of the matrix and the vectors such that the maximum number of significant digits can be retained on a desk calculator. Some discussion on scaling is given in the appendix.

taking a sample of N sets of observations, determining the interval, and then taking repeated observations on the dependent variable.

It should be noted that the basic calculations carried out for estimating the parameters of a regression model would yield most of the information needed to calculate tolerance intervals. Thus a small amount of additional work is needed to derive tolerance intervals. Although it is more complicated to calculate tolerance intervals than confidence intervals, the main computational burden for either case is to obtain the factor $1/N'$, as indicated in (9).

The reader should be aware that the derivation of tolerance intervals as well as confidence intervals hinges on the supposition that there is no structural change from sample period to forecast period.[15] Furthermore, the usefulness of these statistical measurements of forecast reliability depends on the validity of the assumptions on which a regression model is based. The above discussion is confined to a method of presenting the forecast results from least squares regression models. For those who are interested in the forecast theory pertaining to a complete econometric model, see the recent work by Brown and Hooper, et al.[16]

Appendix: Some Notes on Scaling

If calculations involved in a regression analysis are to be carried out on a desk calculator, it is a common practice to scale observations on each variable by some powers of 10 such that the absolute value of each element in the sample moment matrix will be between 0.1 and 10. This eliminates excessive rounding errors that are most likely to occur in the process of inverting the moment matrix.

In order to calculate the factor $1/N'$ as in (9), the inverse of the sample moment matrix of independent variables has to be known. This inverse matrix is available as a by-product of the basic computations required to estimate the parameters of the regression model. However, if elements of the moment matrix have already been scaled, it is then necessary to adjust elements of the inverse matrix back to their original magnitude before it is used to carry out the computation indicated in (9).[17]

It is shown here that this last step can be eliminated if elements of the vectors that are to premultiply and postmultiply the inverse matrix are scaled by the same powers of 10 as those initial observations on the inde-

[15] L. Hurwicz gives an excellent discussion on prediction and structural changes in *Statistical Inference in Dynamic Economic Model*, Cowles Commission Mono. 10, John Wiley & Sons, Inc., New York, 1950, pp. 266–73.

[16] T. M. Brown, "Standard Errors of Forecast of a Complete Econometric Model," *Econometrica*, Vol. 22, April 1954, pp. 178–92. J. W. Hooper and A. Zeller, "The Error of Forecast for Multivariate Regression Models," Unpub. Cowles Found. Disc. Paper No. 77, 1959.

[17] This is the method suggested by Friedman and Foote in *Computational Methods for Handling Systems of Simultaneous Equations*, Agr. HB. No. 94, U. S. Dept. Agr., p. 19.

pendent variables were scaled. To illustrate this point, consider the following simple case:

There are two fixed variables and T observations on each of them. Let z_{t1} and z_{t2}, for $t=1, \cdots, T$, denote them, and let A denote the unscaled moment matrix:

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \tag{14}$$

where

$$a_{11} = \sum_t z_{t1}^2, \qquad a_{12} = a_{21} = \sum_t z_{t1} z_{t2}, \qquad a_{22} = \sum_t z_{t2}^2.$$

If z_{t1} and z_{t2} are multiplied by 10^a and 10^b, where a and b are some integers, the resulting moment matrix is

$$M = \begin{pmatrix} a_{11}\ 10^{2a} & a_{12}\ 10^{a+b} \\ a_{21}\ 10^{a+b} & a_{22}\ 10^{2b} \end{pmatrix}. \tag{15}$$

Hence, its inverse is

$$M^{-1} = \frac{\begin{pmatrix} a_{22}\ 10^{2b} & -a_{21}\ 10^{a+b} \\ -a_{12}\ 10^{a+b} & a_{11}\ 10^{2a} \end{pmatrix}}{(a_{11}\ a_{22} - a_{12}\ a_{21})\ 10^{2(a+b)}}. \tag{16}$$

If we let m^{ij} and a^{ij} stand for elements in the ith row and the jth column of M^{-1} and A^{-1} respectively, from (16) we see that

$$\begin{aligned} m^{11} &= a^{11}\ 10^{-2a}, \\ m^{22} &= a^{22}\ 10^{-2b}, \\ m^{12} &= m^{21} = a^{12}\ 10^{-(a+b)}. \end{aligned} \tag{17}$$

Define row vectors z and $\bar{z}$ as follows:

$$z = (z_{T+1,1}\ z_{T+1,2}), \qquad \bar{z} = (z_{T+1,1}\ 10^a\ z_{T+1,2}\ 10^b).$$

Thus, from (17),

$$zA^{-1}z' = \bar{z}M^{-1}\bar{z}'. \tag{18}$$

In general, when elements of matrix A are not of the same order of magnitude, it is more efficient to calculate the right hand side of (18). Although the above proof was carried out for the case of two fixed variables, it can be shown that (18) would hold for the general case involving a $K \times K$ moment matrix.

Thus in order to calculate $1/N'$ for the example given in p. 917, a preferred way of setting up a computation is as follows:

$$\frac{1}{N'} = (0.1\ 0.4\ 0.11)\begin{pmatrix} 0.15 & 0.69150 & 0.1838 \\ 0.69150 & 3.21083032 & 0.83574184 \\ 0.1838 & 0.83574184 & 0.23379128 \end{pmatrix}^{-1}(0.1\ 0.4\ 0.11)'.$$

Clearly this scaling procedure can also be used for calculating the standard error of forecast.

REFLECTIONS ON "DYNAMIC PROGRAMMING MODELS"

WILFRED CANDLER[1]
University of New England, Armidale, N.S.W., Australia

THIS note is intended to add to, rather than to criticise, Loftsgard and Heady's "Application of Dynamic Programming."[2] These additional notes are thought worthwhile since inter-temporal programming could be a very real aid to farm and home planning.

Just as decisions with respect to the farm affect the home, and vice-versa, so decisions made this year, affect the farm and home in subsequent years. In particular, prodigal or frugal behaviour this year may markedly affect the income earning capacity of the farm the next and subsequent years.

The original article points out that many farm and home planning problems are "dynamic" (in the Hicksian sense of having dates attached to inputs and outputs).

In particular, the income which is the output from one production period is an input for the next period. Often an important farm and home planning problem is how the output should be divided between family living and farm input for the next production period. Obviously, the supply of labour, price expectations, and even level of management *can* be expected to change over time. In fact, however, the crucial problem is often the implications, with all other things unchanged, of progressively, increasing supplies of working capital. In this latter case, special computing procedures can be used.

The first reflection which needs emphasis is that *formally* there is no difference between normal linear programming and (Hicksian) dynamic linear programming.[3] In each case there is a series of restrictions, activi-

[1] The author is indebted to Earl O. Heady for critically reading the first draft of this paper.

[2] Laurel D. Loftsgard and Earl O. Heady, "Application of Dynamic Programming Models for Farm and Home Plans," *J. Farm Econ.*, 41:51-62 (Feb. 1959).

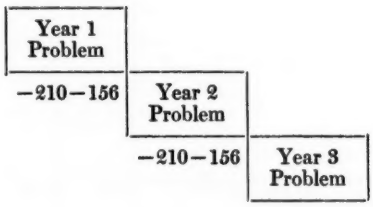
[3] There are, of course, important differences between Loftsgard and Heady's use of the term "dynamic programming" and the use established by Bellmann in his many articles and books on dynamic programming. See, for instance, Richard Bellmann, *Dynamic Programming*, Princeton Univ. Press, 1958.

ties and input-output coefficients. Any two factors which are not perfect complements or perfect substitutes should be considered as separate resources. The resources may be imperfect substitutes due to qualitative differences (land, labour, capital) or due to the influence of time. Time may be of importance, as in standard linear programming, due to labour *in different months* being poor substitutes, or due to land being available in different seasons. In a Hicksian problem land, labour and capital are available *in different years.*

Activities may differ qualitatively (level of fertilizer, management or rotation intensity) or due to time. Time separates the activities in the Hicksian problem since the same sort of activity can be pursued in any one of a number of years.

Since there is no formal difference between the Hicksian and normal programming problem, Hicksian problems *can* be solved using the lay-out suggested by Table 1 of the Loftsgard and Heady article.

The second reflection is that Hicksian problems are characterized by a block-diagonal matrix of input-output coefficients. Hence any economies from recognising a problem as Hicksian are likely to be associated with the matrix being block-diagonal. Table 1 of Loftsgard and Heady can be summarized as



The input-coefficients in each of these blocks are the same. The problems differ due to the amount of capital (and incidentally labour) available for employment each year.

Now *if the only difference between years* is the supply of capital, as is suggested by the description of the "case farm situation," then we have a *parametric programming problem.* The parameter to be varied is the supply of capital, and the appropriate computing routine has been described elsewhere.[4]

Table 1 of Loftsgard and Heady describes a Hicksian problem with two enterprises (Hogs and Beef) produced in each of three years, and two limiting resources (Capital and Labour) in each of three years. The

[4] Heady, Earl O. and Candler, Wilfred, *Linear Programming Methods,* Ames: Iowa State College Press, 1958; and Candler, Wilfred, "A Modified Simplex Solution for Variable Capital Supply," *J. Farm Econ.,* 38:940 (Nov. 1956).

Capital supply in year 1 is \$7,000. The living requirements are \$3,600, \$4,000 and \$3,900 in years 1, 2 and 3 respectively. The production problem is the same each year, except for the supply of capital and the supply of labour (labour is allowed to increase from 700 to 720 to 750 units).

Initially, it will be convenient to simplify this problem still further by assuming the labour supply is constant at 700 units in each year. In this case we have *a simple parametric programming problem* with capital

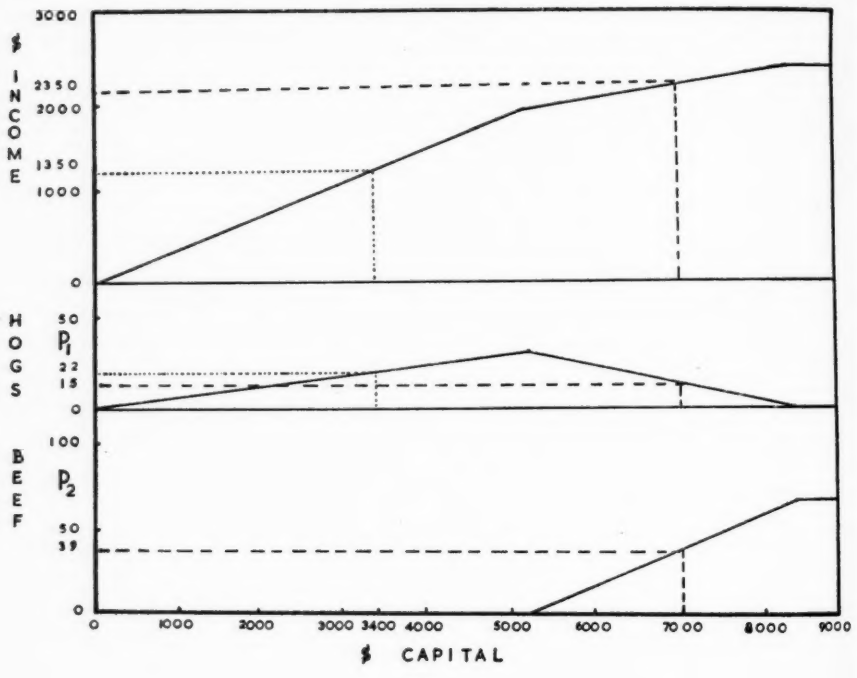


FIG. 1

supply as the parameter to be modified. The solution of this problem can be expressed graphically as in Figure 1.

The author believes that results presented in the form of Figure 1 should be of considerable assistance in farm and home planning. The figure, once explained, makes sense, and the results of investing or disinvesting in the farm business can easily be seen. Consider a farm with \$7,000 of initial working capital. Then looking at the income graph of Figure 1 we can see that this amount of capital will produce an income of (approximately) \$2,350. If the farm family plans to spend exactly \$2,350, they will commence year 2 with the same amount of capital as they commenced year 1. If they spend *more than \$2,350* on consumption, they will reduce the amount available for investment in the farm, and con-

sequently the income they can expect. If they spend *less than $2,350*, they will be able to increase farm investment, and hence income in subsequent years.

The income $2,350 would be produced by 15 units of hogs and 39 units of beef (P_1 and P_2 in Figure 1).

Now reverting to Loftsgard and Heady's simple example, the farm family has $7,000 available initially, but plans to spend $3,600 on consumption in the first year. This leaves $3,400 for investment in the farm. Consulting Figure 1 it is easy to see that, with $3,400 of capital, the optimum plan is the production of 22 units of hogs. This will yield an income of $1,350. Adding this $1,350 to the $3,400 used to produce it, the farm family has $4,750 of capital available at the beginning of the second year. The planned consumption is $4,000. This would leave only $750 for investment in the farm, and bankruptcy would follow in year 3. The importance of relating farm and home planning could not be more graphically illustrated. Consumption decisions affect farm productivity and hence income in subsequent years. It is clear that one cannot think of an absolute schedule of consumption requirements, but consumption must be adjusted to allow survival of the farm and home unit.

With the aid of Figure 1, the above discussion could be conducted with the farm family in the course of a farm and home planning session.

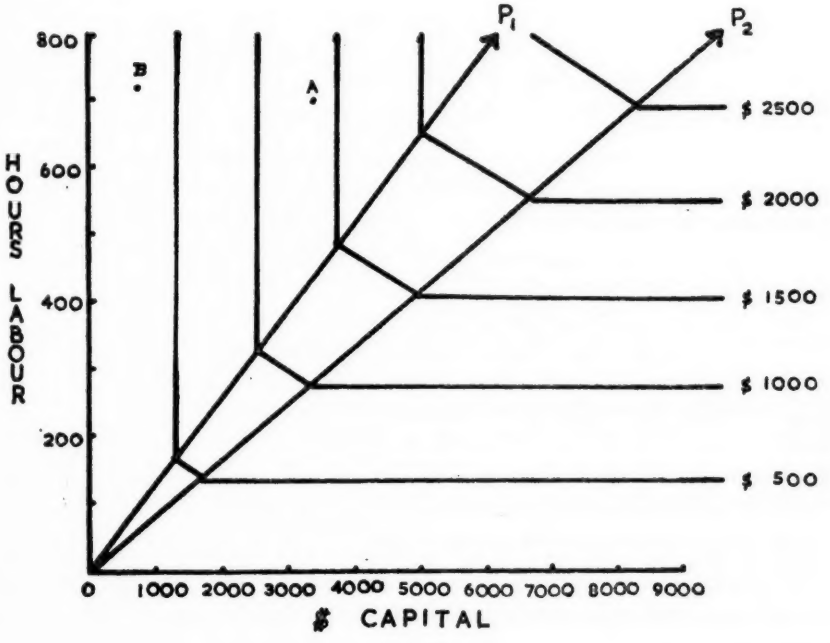


FIG. 2

Further, Figure 1 would allow the extension personnel to indicate at once the results of revised consumption plans, and hence the farm family could optimize their inter-temporal (or Hicksian) consumption pattern.

If the planning situation requires the analysis of possible variations in two factors, say, capital and labour, then an income map such as Figure 2 can be drawn. This gives the maximum attainable income for any given resource combination. Points *A* and *B* represent the projected resource combinations available in the first two years (as given by Table 1 of the Loftsgard-Heady article). This income map illustrates very clearly that the marginal product of labour is zero and that there is no hope of substituting labour for capital. In this situation the farm family cannot hope to compensate for its "high" level of consumption by working harder.

The third reflection is that the best way of "discounting" returns is to compound them, by making specific provision for a capital transfer activity. To transfer capital from year 1 to year 2 the activity should have +1 in the year 1 capital row and −1.05 (for a 5% rate of interest) in the year 2 capital row, zero's elsewhere. This avoids having to explicitly discount future costs and returns. It thus reduces the chance of logical or transcription errors.

In particular, using the parametric programming approach, where we are attempting to maximize income in year 2, we would have:

		Hogs	Beef	Bank
	C_j	210	156	1.05
Capital	K	150	120	1
Labour	700	20	10	0

where K is the parameter, initial capital supply, to be varied.

Using the Loftsgard-Heady tableau and immutable consumption requirements, we would be aiming to maximize income in year 3, say, subject to meeting the consumption requirements in years 1 and 2. The tableau could then appear:

	C_j	Hogs_1 0	Beef_1 0	Bank_1 0	Hogs_2 0	Beef_2 0	Bank_2 0	Hogs_3 210	Beef_3 156	Bank_3 1.05	Consumption M
Capital_1	7,000	150	120	1							8,600
Labour_1	700	20	10	0							0
Capital_2	0	−210	−156	−1.05	150	120	1				4,000
Labour_2	700				20	10	0				0
Capital_3	0				−210	−156	−1.05	150	120	1	8,900
Labour_3	700							20	10	0	0
Consumption	1							0	0	0	1

The fourth reflection is that the crux of the Hicksian problem is likely to be how much money should be earned in each year? For this problem it would be more appropriate to avoid rotation activities and think, rather, of separate crops.

A possible set of technical relationships suggested by a class of graduate students discussing this paper, would be:

$F_1 \rightarrow C \rightarrow F_2$
$F_1 \rightarrow M \rightarrow F_1$
$F_2 \rightarrow C \rightarrow F_3$
$F_2 \rightarrow M \rightarrow F_1$
$F_3 \rightarrow C \rightarrow F_4$
$F_3 \rightarrow M \rightarrow F_2$
$F_4 \rightarrow C \rightarrow$ Erosion
$F_4 \rightarrow M \rightarrow F_5$
$F_5 \rightarrow C \rightarrow F_4$
$F_5 \rightarrow M \rightarrow F_1$

Class of Land	Yields	
	Corn (bu.)	Meadow (tons, Hay)
F_1	100	2
F_2	80	1.9
F_3	65	1.7
F_4	Erosion	1.4
F_5	65	1.7

This approach recognises explicitly that if you use Fertility 1 land (F_1) for corn (C) you have, next year, Fertility 2 land (F_2) available. The possibility of erosion and the restorative properties of meadow are explicitly recognised. Levels of fertilizer could also be taken into account.[5] Obviously, this approach will need many more restrictions (supply of F_1, F_2, F_3, F_4 and F_5 land in each year) than the rotation approach and hence would prevent any great gain from parametric programming.

The guiding principle should be, of course, *the aim of the study.*

The fifth reflection is that, where applicable, parametric programming will greatly reduce the computing burden. A problem with 7 restrictions and 10 activities in each of 8 years would lead to a matrix of $(7 \times 10) \times (8 \times 10) = 5{,}600$ coefficients, mostly zero, if tackled as a whole. If 6 activities came in in each of 10 years this would mean 60 iterations of a matrix 70×80—a serious computing burden even for an American high speed digital computer.

Tackled parametrically, the same problem would give a matrix of 56 input coefficients, and allowing for even 10 iterations by the parametric procedure, we have a significant saving.

The sixth reflection is that this procedure of Loftsgard and Heady is likely to be very useful in farm and home planning. By analysing the nature of the production problem and especially the influence of investment on income, this procedure will permit the farm family to obtain improved insight into their farm problem. With this better insight the decision makers can be expected to improve their allocation of income between production and consumption. In particular the possibility of using block programmes in place of block budgets should be considered. If the bench-mark farm coefficients were altered to give yields and resource supplies more appropriate to the farm being studied, a digital

[5] A T.V.A. sponsored study by Earl O. Heady and Wesley G. Smith has, in fact, used very much this approach.

computer would provide the corresponding "optimum plan" for between $5 and $10. This could then be interpreted arithmetically, and, if necessary, other alterations could then be considered.

Farm economists have taken an important lead in the development of linear programming techniques. They should probably expect to have to go more than half way in showing home economists and others how these techniques can be used in farm and home planning.

CORRECTION

In the article, "Impact of Technical Advance and Migration on Agricultural Society and Policy," by John M. Brewster, published in the last Proceedings (*Journal of Farm Economics,* 41:1169-84, December 1959), on page 1170, 13th line, the word "observe" should instead be "deserve," making the sentence read, "An equally fiendish punishment is the feeling that one is so barren of meritorious capabilities that he is unable to deserve the esteem of anyone."

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REVIEWS

Antitrust Policy, An Economic and Legal Analysis, Carl Kaysen and Donald F. Turner. Cambridge: Harvard University Press, 1959. Pp. xxiii, 345. $7.50.

Antitrust theory is the major component of the product that general economists call "industrial organization" and a substantial part of the more encompassing offering that British economists call "industrial economics." It is also properly a part of offerings in agricultural marketing, agricultural policy, and/or agricultural business administration. Treatises on the subject sell in a market with low concentration, significant product heterogeneity, and—judging by the continual effusion—easy entry.

The latest entrant is a very desirable kind of joint venture—the collaboration of a Professor of Economics and a Professor of Law, both at Harvard. In addition, the volume, as E. S. Mason reports in a worthwhile preface, is an outgrowth of discussions over several years among fourteen prominent legal and economic specialists in the field. It has the further credential that Bain urged readers of his new text to refer to it for "articulation of this basic approach to revising . . . Section 2 of the Sherman Act."[1]

One chapter in the book, plus appendices, provides a welcome addition to the fund of information about market structures in the American economy. Refining government data, the authors and Merton J. Peck classify manufacturing and mining "industries" by geographic segmentation, supply concentration, value of shipments, and types of products (consumer-producer, durable-non-durable). They also, for "exempt" sectors, tabulate income originating, regulatory agencies, nature of regulation, and supply concentration.

Primarily, however, the book is concerned with appraising and rewriting the law and administration of antitrust policy—with a minimum of restatement or chronicling.[2] The authors cover virtually the same ground as does Corwin Edward's *Maintaining Competition*, and they reach similar conclusions—although it would be a mistake to suppose that that remarkable treatise is now obsolete.

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[1] J. S. Bain, *Industrial Organization* (New York, 1959), p. 609.

[2] For these, good references are *Report of the Attorney General's National Committee to Study the Antitrust Laws* (Washington, D.C., 1955) and D. Dewey, *Monopoly in Economics and Law* (Chicago, 1959). For the status of cooperatives (a subject unmentioned by Kaysen and Turner), see the Attorney General's Committee, *op. cit.*, pp. 306-313; L. S. Hulbert and R. J. Mischler, *Legal Phases of Farmer Cooperatives*, Farmer Coop. Serv. Bull. 10 (Washington, D.C., 1958), pp. 156-180; R. A. Bicks, "Antitrust and the Farmer Cooperatives," *The Cooperative Accountant*, Fall 1959, vol. 12, pp. 3-12; and—most important—Maryland and Virginia Milk Producers Association, Inc., vs. U.S., U.S. Supreme Court, Oct. term, 1959, Repts. Nos. 62 and 73 (May 2, 1960).

The authors make many policy recommendations, but one stands out as clearly the most important and I will refer only to it. The proposal is to enact a prohibition on the possession of "unreasonable market power," with divestiture specified as the normal remedy. The effect of this proposal would be to add a prohibition on monopoly structure to the existing prohibitions on monopolizing conduct, and to make structural revision frequent instead of rare.

Market power (like inadequate alternatives, the password of the 1940's) is a metaphysical concept. It "is of no practical use unless we want to treat every deviation from [add: static] pure competition as an offense."[3] But what the authors mean is at least this: persistently high concentration in a recognizable market, plus (as proof of high entry barriers and joint action) "persistence of profits that are abnormally high, taking into account such factors as risks and excess capacity"—except that "Market power shall be conclusively presumed where, for five years or more, one company has accounted for 50 percent or more of annual sales in the market, or four or fewer companies have accounted for 80 percent of sales."[4] Three defenses are to be allowed: scale economies, patents, and superior prices or products attributable to innovation or efficiency. Otherwise, it is "unreasonable" market power, and division of one or more defendants would usually follow.

There are two groups of reasons why I remain unpersuaded.

I. The statute would measure poorly against Brewster's standards of fairness and feasibility.[5] We have the prospect of (A) struggling with the practically insoluble problem of market delineation,[6] (B) protracted and extravagant litigation, (C) enormous discretion left to judges,[7] (D) losses

[3] M. A. Adelman, "Integration and Antitrust Policy," *Harvard Law Rev.*, 1949, vol. 63, p. 48.

[4] Pp. 266, 267. See also pp. 8, 75-78, 90, 101, 112, 245.

[5] See K. Brewster, Jr., "Enforceable Competition: Unruly Reason or Reasonable Rules?" *Amer. Econ. Rev.*, May 1956, vol. 46, pp. 482-489.

[6] The authors' brief remarks on the subject (pp. 101-102, 134, 295-296) indicate that they want to include supply considerations in delineating a market (as distinct from measuring its concentration). For this debate see R. L. Bishop, "Reply," *Amer. Econ. Rev.*, June 1955, vol. 45, pp. 382-386 and the literature cited therein.

[7] "Once that central focus on market structure is accepted, there is no alternative, if the anomaly of condemning the innocent along with the guilty . . . is to be avoided, to judging the lawfulness of a large enterprise by 'results,' 'business performance,' or 'efficiency.' For that task, courts are not fitted." M. W. Watkins, book review, *Amer. Econ. Rev.*, Sept. 1957, vol. 47, p. 750. "To the extent that they do not make their directive clear, legislatures may expect that by interpretation . . . the decision-maker will himself narrow his own mandate. Feasibility argues against bestowing or accepting the moral overload of unbridled power." Brewster, *op. cit.*, p. 486.

This sort of overload is inherent in the defenses specified by the authors. Improvements in processes, products, and merchandising are continual in manufacturing; and success could always be attributed to them. Furthermore, four kinds of economies of relative size are always *potentially* available: (1) elimination of needless duplication,

inflicted on innocent stockholders,[8] and, perhaps most important, (E) discouragement of aggressiveness and frugality by firms that might appear too dominant or too lucrative. These pains might be worth suffering if substantial gains were likely. But are they?

II. The evils of high concentration are undemonstrated. Bain's studies give us some nontautological evidence of an association between industry profit rates and seller concentration.[9] A. Even supposing that higher concentration tends to produce higher profits, however, it is not clear that the absolute levels are in some sense too high. J. M. Clark and Joan Robinson have argued that profits in unconcentrated industries may average less than zero.[10] Finding positive profits in concentrated industries—to the successful firms, over short periods, and for multiple products—is not sufficient to establish that the profits are excessive in view of their life expectancy and relative to the risks, innovations, cost performance, and mandates for reallocation of the firms involved. To rely on their apparent association with high concentration[11] would be circular reasoning. Indeed, there is some presumption that profits are not excessive *if* countervailing

(2) minimization of transport costs, (3) coordination of interacting decisions, and (4) reduction of risk. (On the third, see M. Dobb, *Soviet Economic Development Since 1917* (New York, 1948), pp. 6-11, and T. Scitovsky, "Two Concepts of External Economies," *J. Pol. Econ.*, Apr. 1954, vol. 62, pp. 149-150. On the fourth, see Kaysen and Turner, p. 116, fn. 22, and Dewey, *op. cit.*, p. 34.) There is a fundamental asymmetry: small firms are decentralized; a combination can (but in practice may not) centralize or decentralize as appropriate.

[8] That is, if the judges even of the proposed Economic Court can bring themselves to inflict the losses. See Dewey, *op. cit.*, ch. 17.

[9] J. S. Bain, "Relation of Profit Rate to Industry Concentration: American Manufacturing, 1936-1940," *Quar. J. Econ.*, Aug. 1951, vol. 65, pp. 293-324; *Barriers to New Competition* (Cambridge, 1956), pp. 190-201. Admittedly, a sample of 42 (depression period) and/or 20 (postwar) "industries" is not large compared to the very important extraneous factors that must be "averaged out." Furthermore, the data are rationalized as a dichotomy between industries above and below 70-percent-by-8 (or 75-80 percent for a theoretical industry: *Industrial Organization*, p. 414); this dichotomy, although statistically highly significant, seems a priori implausible compared with a monotonic increase all through (and beyond) Bain's five classes of oligopoly (*Industrial Organization*, pp. 124-133). Yet a functional fit was "obviously so poor that the inference of a rectilinear or other simple relationship of concentration to profits is not warranted" ("Relation," p. 313).

Apparently the authors also have a simple relationship in mind. True, at p. 9 they write as if it is a matter of indifference whether there are two, three, or four sellers. (This is the typical position—found here at pp. 48 and 59—of those who expect market structure to compel, rather than conduce to, good performance.) But see pp. 114-115, 194, and 243 on degrees of oligopoly, and pp. 61 and 71 on conducing rather than compelling.

[10] J. M. Clark, *Studies in the Economics of Overhead Costs* (Chicago, 1923), pp. 437-439; "Toward a Concept of Workable Competition," *Amer. Econ. Rev.*, June 1940, vol. 30, p. 250. J. Robinson, "The Impossibility of Competition," in E. H. Chamberlin, ed., *Monopoly and Competition and Their Regulation* (London, 1954), p. 254.

[11] *Industrial Organization*, p. 414.

power exists—particularly that based not on oligopsony but on the practicability of self-supply, of specification buying, and/or of private labeling.[12]

B. Even if profits are excessive, the loss is small. According to the authors[13] and to Bain,[14] the loss is of two kinds—redistribution and reallocation. 1. The distribution argument rests on the idea that excess profits "result in a larger share of the national income going to enterprise owners,"[15] in a situation where "less than one percent of all American families owned over four-fifths of all publicly held stocks owned by individuals."[16] However, when excess profits have already been capitalized in security prices, their existence aggravates inequality no more than does other property income. To be sure, capital losses could be inflicted on the stockholders; but the value position underlying this whole argument usually leaves expropriation to the tax system. And how much is involved? Bain estimates that the adjusted after-tax excess profits of all corporations—excess only in the sense that imputed interest is already subtracted, not innovation rewards, etc.—amount to 2.0-2.5 percent of national income.[17] Reduce this to, say, 1.0 percent to acknowledge that manufacturing and mining originate only one-third of national income—but are heavily corporatized and, together, above average in profitability.[18] Now, to acknowledge that differences in concentration may explain half of industries' differences in profit rates, reduces the figure to 0.5 percent of national income.[19]

2. The misallocation argument supposedly derives from (static) welfare economics. But there are missing links. Long-run profits to an "industry" do not imply long-run profit margins on changing and differen-

[12] The authors (at pp. 153 and 194), like Bain (*Industrial Organization*, p. 416), summarily dismiss the usefulness of countervailing power (a situation interpreted by M. A. Adelman—see especially "The Large Firm and Its Suppliers," *Rev. of Econ. and Stat.*, May 1949, vol. 31, pp. 113-118—and enthroned in J. K. Galbraith, *American Capitalism, The Concept of Countervailing Power*, 2d ed., Boston, 1956). It is true that Stigler has undermined its supposed inevitability ("The Economist Plays with Blocs," *Amer. Econ. Rev.*, May 1954, vol. 44, pp. 7-14) and that he and W. Adams ("Competition, Monopoly, and Countervailing Power," *Quar. J. Econ.*, Nov. 1953, vol. 67, pp. 469-492) and others have shown that good performance is not compelled. But this hardly disposes of the idea—as Stigler and Adams recognize.

[13] E.g., pp. 5, 33.

[14] *Industrial Organization*, p. 371.

[15] *Industrial Organization*, p. 371.

[16] Quoted by V. Perlo, " 'People's Capitalism' and Stock Ownership," *Amer. Econ. Rev.*, June 1958, vol. 48, p. 339.

[17] *Industrial Organization*, p. 384.

[18] Construction, trade, and services are less relevant to the trust-busting proposal at issue since they (probably) are rarely highly concentrated except in local markets that are small relative to scale economies.

[19] Half seems generous. One-ninth is the figure for a linear fit, since Bain obtained $r = .33$ ("Relation," p. 313).

tiated individual products. Price above long-run average cost on individual products does not imply price above short-run marginal cost.[20] A welfare loss from $P > MC_S$ when $P = MC_S$ elsewhere in the economy does not imply a loss from $P > MC_S$ when $P > MC_S$ is (and, as the authors realize,[21] ought to be) also characteristic elsewhere. But even making these leaps, how much is involved? The aggregate welfare loss associated with misallocation in the principal relevant sector, manufacturing, may amount to 0.1 percent of national income.[22]

C. "It is not [price, quality, promotional] competition which counts but the competition from the new technology, the new source of supply, the new type of organization. . . . [This kind is] so much more important that it becomes a matter of comparative indifference whether competition in that ordinary sense functions more or less promptly; the powerful lever that in the long-run expands output and brings down prices is in any case made of other stuff."[23] And what is the relation between concentration and creative destruction? According to the authors, "The fundamental information we require for adequate discussion is lacking."[24] The same is true for other dimensions of performance that also count for more than do profits—sales promotion, product variety, social costs, input supplies, labor relations, and even efficiency.[25] That the substantial gains mentioned in point I, above, will result seems hard to maintain when the case against high concentration rests on only tenuous links with only its less important consequences.

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[20] The authors' argument is based on the idea that long-run average cost (AC_L) generally equals long-run marginal cost (MC_L), so that zero long-run profits would imply $P = MC_L$. (Kaysen and Turner, p. 62, fn. 19. *Industrial Organization*, p. 371.) Aside from the questionable assumption, and neglecting indivisibilities, it is correct that welfare theory says that long term commitments should be based on an output *intention* corresponding to $P = MC_L$. However, welfare theory also demands, regardless of previous commitments, that in each indivisible production period, or short-run, output be adjusted until MC_S, reflecting only short-run variable costs, equals price. And $P = MC_S$ is inconsistent with $P = MC_L$ unless demand is both invariable and predictable and plant size is continuously optimal.

[21] P. 65.

[22] A. C. Harberger, "Monopoly and Resource Allocation," *Amer. Econ. Rev.*, May 1954, vol. 44, p. 86. Stigler prefers "$2,000,000 a year for every economist." "The Statistics of Monopoly and Merger," *J. Pol. Econ.*, Feb. 1956, vol. 64, p. 35.

[23] J. A. Schumpeter, *Capitalism, Socialism, and Democracy*, 3d ed. (New York, 1950), pp. 84-85. For critical comment see especially E. S. Mason, *Economic Concentration and the Monopoly Problem* (Cambridge, 1957), chs. 5, 17.

[24] P. 85. Three of the most useful studies are G. W. Nutter, "Monopoly, Bigness, and Progress," *J. Pol. Econ.*, Dec. 1956, vol. 54, pp. 521-527; G. J. Stigler, "Industrial Organization and Economic Progress." in L. D. White, ed., *The State of the Social Sciences* (Chicago, 1956); J. Schmookler, "Technological Progress," in E. S. Mason, ed., *The Corporation in Modern Society* (Cambridge, 1959).

[25] Interestingly, both the authors (p. 9) and Bain (*Industrial Organization*, p. 155) substantially reject the idea that high concentration may produce diseconomies of scale.

Where does this leave us? In the present state of knowledge, it leaves us with prohibitions not on structure but on conduct (which in principle includes mergers)—prohibitions that bear a recognizable relation to efficiency or to "ethical" behavior—and with positive kinds of public policy.[26]

STEPHEN H. SOSNICK

University of California, Davis

The Design of Development, Jan Tinbergen, Baltimore: The Johns Hopkins Press, 1958. Pp. vi, 99. $2.50.

This slim, small volume, written in 1955, is a product of the International Bank's Economic Development Institute. Michael Hoffman's introduction states it has been used extensively there as a basis for discussion of development policies, programming, and project appraisal, and is now published for the use of a wider audience.

Dr. Tinbergen's admirers will be amazed to know that there is not a single equation, chart, or mathematical symbol in the 69 pages of the main text. Even the 21 pages of appendix, with more detailed consideration of specific issues, are illustrated only by simple tables and arithmetic —an amazing *tour-de-force* for one of the founders of the International Econometric Society! But this is appropriate in a practical "how-to-do-it" book for those concerned with realistic procedures in preparing national development programs.

The book includes programming general development, appraising individual projects, establishing priorities, determining fields of public and private action, and methods of stimulating private investment. It is written in a simple, clear, compact and easy style. Despite its brevity and simplicity, it touches on almost every issue raised in the many theoretical treatises on economic development, often with illuminating flashes of insight. The writing shows the authoritative assurance of a man who for many years has been engaged in the art of making practical economic plans and programs, in steering actual economic development, and in helping to develop the basic theory. Each page and often each sentence is full of ideas and meaning. Practical examples, drawn largely from the author's own experience in the Netherlands, are frequent and useful in clarifying specific issues and problems, though they are not always applicable to corresponding problems in less developed countries.

One of the book's strongest features is the brief, clear discussion of methods of stimulating private investment. This covers tariff protection; subventions; tax provisions; programming; information, encouragement, and demonstration; and financing. Also discussed are "minor facilities"

[26] See especially A. E. Kahn, "Standards for Antitrust Policy," *Harvard Law Rev.*, Nov. 1956, vol. 67, p. 28.

or what is now more often called "infrastructure"—transportation; power; educational, social, and medical facilities; etc. The realism and simplicity of this discussion compares very favorably with the theoretical, complicated, but often abstract presentation of the same problems by other and later writers such as Hirschman.[1]

Agricultural economists will find a number of points of special interest. One is the suggestion that methods of extension teaching and demonstration, long used for agriculture, should also be applied in industry, such as by establishing publicly-owned demonstration plants (page 58). Another is the emphasis on the use of price forecasts, familiar in agricultural outlook work and long-term projections, in selecting products for expansion, especially for export (page 56). The economy of supplying such information by national and international action is also emphasized. (F.A.O. has started on making such projections for agriculture on a world basis, in cooperation with countries and other international agencies.) The "avoidance of international duplication" in production by the international coordination of development programs (one of the basic objectives of F.A.O.) is also stressed (pp. 24-25). While agriculture is mentioned briefly, the book is largely devoted to the selection and planning of non-agricultural sectors of the economy, with no examination of the special problems of agricultural development such as land reform.

While the place of education in economic development is mentioned briefly, in the opinion of the reviewer education and manpower training are given insufficient attention—which is a general fault of most books on economic development—and neither "education" nor "training" appear in the otherwise excellent index.[2]

The book has some other minor shortcomings. One is the heavy dependence on illustrations from the Netherlands, and on conclusions based on experience there, often only slightly applicable to less-developed countries. However, the effect of differences in the relative scarcity and costs of labor and capital in developed and underdeveloped countries (often overlooked by American technicians newly working abroad, in recommending what is "efficient") is clearly recognized.

Another doubtful point is the proposed use of "accounting prices" rather than actual or forecasted real prices, in appraising projects or priorities. This is based on the concept that wages in underdeveloped countries tend to be held at levels above the real value of labor, and

[1] Albert Hirschman, *The Strategy of Economic Development*, Yale University Press, 1958.

[2] Planning for and creating the needed manpower is the most neglected aspect in most actual development programs. See J. Douglas Brown and Frederick Harbison, *High-Talent Manpower for Science and Industry*, Industrial Relations Section, Princeton University, 1957, 97 pp., and Frederick Harbison, *High-Level Manpower for Nigeria's Future*, Industrial Relations Section, Princeton University, 1960, 48 pp.

that capital is provided at interest rates below its true value. "Market wages will as a rule be higher than accounting wages; and interest rates charged by international institutions may be lower than accounting rates. . . . Both deviations tend to slant the calculations in the same direction, in favor of too capital-intensive technologies." (page 50) While there is some basis for this argument, it seems to be rather over-stated in view of the extremely low wages actually prevailing in many over-populated underdeveloped countries, such as India and Pakistan with wages for common labor only 20 to 40 cents a day, and with uncontrolled domestic interest rates exceedingly high. The suggestion of using a series of different "accounting prices," and seeing what differences in project choice would result from various assumed differences in the wage rate/interest rate ratio, is however an interesting one.

One other minor flaw is the failure to recognize more clearly the long lag required in bringing newly established projects or industries up to normal levels of efficiency, even for the equipment used. This lag is quite apparent even in highly-developed countries, as in military aircraft and shipping mass production in the U. S. during World War II. While some implied recognition is given to this in the suggested 5-year limit on tariff preferences for infant industries (page 52), the proposal for the use of cost estimates (pages 22-24) tends to ignore it. My own experience and observation suggests that project construction costs in underdeveloped countries tend to exceed those estimated, while production per man often lags far below that expected, even many years after the project is completed. This makes the use of costs or technical coefficients observed in other countries a questionable procedure.

Despite these minor questions—such as could be raised about almost any text in the field—the book as a whole would be a splendid text for elementary courses in economic development, and a useful introduction or background reading for more advanced courses on the theory of economic development. It should be studied by economists engaged in practical economic planning or program-making in their own countries, or serving as technical advisers on such problems in other countries.

MORDECAI EZEKIEL

F.A.O., Rome

Marketing Policies for Agriculture, James R. Bowring, Herman M. Southworth and Frederick V. Waugh. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1960. Pp. xi, 276. $7.95 (Trade Ed., Text, $5.95).

This book emphasizes principles. Aside from several pages devoted to the scope of the nation's agriculture, relatively few facts and figures are included. The dominant theme is decision making and the application of economic theory to marketing problems. The authors spend a consider-

able portion of their text—and rather effectively, in this reviewer's opinion—in their analysis of the manifold decisions which must be made by the numerous agencies and individuals who participate in the marketing process. An analysis of the basic functions of marketing which are covered in the standard texts on agricultural marketing and agricultural prices is contained in the book. However, the chapters on commodity marketing are missing. The instructor who desires to use such materials must supply his own tables or other descriptive data.

The book is organized into four parts: (1) Decisions in the Market; (2) Costs and Allocations; (3) Marketing Policies of Organized Groups; and (4) Marketing Policies of Government.

The material covered in Part 1 relates to the basic functions of marketing, the marketing policies of farmers and marketing firms, the role of price and the concepts of the perfect market and comparative advantage. Here, as throughout the book, stress is placed on the allocative rather than the physical functions of marketing.

Although many economists question perfect competition as a valid concept (e.g., Harold F. Breimyer in this *Journal*, August 1957), it has been customary to accept it as a norm for evaluating the operation of the marketing system. In perfect competition an industry, and its component firms, are in equilibrium when marginal cost equals price and average total cost. Bowring, Southworth and Waugh, in their chapter on "The Perfect Market," state (pp. 58 and 59) that a firm selling its products at marginal cost would go bankrupt since overhead cost is excluded from marginal cost. But may price and marginal cost not exceed all average costs (including overhead) as well as fail to cover overhead costs? It appears that the authors have developed a portion of their analysis of the perfect market in a different context.

Part 2 is concerned with efficiency in the production of marketing services, buying and selling, risk and market development. The presentation on the latter is an excellent one; a realistic analysis is made of product development and advertising. It is here that the authors choose to present the concept of elasticity. They are not primarily concerned with the mechanics of computing elasticity, but rather with getting across to marketing students the meaning of the difference between elastic and inelastic demand functions.

The chapter on the principles of market allocation presents a theoretical discussion of the mechanics of price discrimination. The concepts of marginal revenue and marginal costs (as they were called when I studied them) are dressed in a suit of a different color and are termed marginal returns and marginal payments. Following the theoretical discussion, much of the ensuing material relates to the application of price discrimination throughout the broad spectrum of marketing.

The shortest of the four main portions of the book, Part 3, contains three chapters. Here group action and economic policies are considered. Marketing policies of farmers' organizations and of trade associations are discussed in the final two chapters of the section. Relatively few other marketing texts have up-to-date material on the expanding role played by trade associations in the agricultural marketing field.

The somewhat controversial function of government in marketing comprises the topic of the fourth and final section of the book. Standards, grades, transportation rates, storage operations, improving market facilities, surplus disposal and industry-government cooperation through marketing agreements, etc., are major areas on which the authors continue their excellent presentation. The concluding chapter deals with the role of government and states that a serious student will avoid any dogmatic position about the proper size and scope of government marketing programs.

Export programs and international commodity agreements are treated briefly in the chapter on surplus disposal. In addition, several paragraphs in the book's final chapter deal with foreign economic policy; it is somewhat prophetic that they form the concluding ones in the book. Foreign trade will most assuredly continue to play a very substantial role in the future of agricultural marketing.

In several instances (I noted four) the names of authors referred to in footnotes or in chapter bibliographies are misspelled. Styling in the presentation of bibliographic references with multiple authors is not consistent.

The points criticized, however, are very minor when the book is considered in its entirety. It is concisely written, easily readable, brief as compared with contemporary books in its field and presents its material in a challenging manner. *Marketing Policies for Agriculture* has many gems of philosophy and thought-provoking statements. I see for it a large number of adoptions as a text for upper division courses in agricultural marketing. It is also a useful adjunct to the libraries of farmers, executives of marketing firms, research workers and governmental officials.

CECIL N. SMITH

University of Florida

Industrial Complex Analysis and Regional Development: A Case Study of Refinery-Petrochemical-Synthetic-Fiber Complexes and Puerto Rico, Walter Isard, Eugene Schooler, and Thomas Vietorisz. New York: John Wiley & Sons, 1959. Pp. xvii, 294. $8.75.

The authors have developed and applied methods for measuring the monetary advantages and disadvantages of alternative locations for indus-

trial complexes, i.e., groups of vertically related production processes. Their analysis proceeds in six steps:

(1). Seventy-three production processes are described in terms of their physical outputs and inputs (negative outputs) for arbitrarily specified unit levels. The input and output levels of the seventy-six commodities other than labor and capital are assumed to increase in proportion with process levels. Labor and capital inputs are assumed to obey the fractional power law, and thereby increase in less than proportion with process levels. Labor inputs are separated into skilled chemical-petroleum and semi-skilled textile components. Overhead costs are assumed to vary in proportion with labor and capital costs.

(2). Nineteen industrial complexes covering operations from refinery through synthetic fibre production are selected for further analysis on the basis of "certain empirical observations and reasonable economic judgments" (p. 62). The individual processes are assumed additive, and each complex is described by the algebraic sums of the inputs and outputs of its component processes.

(3). Cost and revenue, i.e., price, differentials between Puerto Rico and alternative mainland locations are estimated for each input and output.

(4). Puerto Rico's preliminary locational advantages are obtained for each complex by multiplying input and output levels by the appropriate price differentials and summing. Puerto Rico is assumed to have an advantage if the sum is positive, and a disadvantage if it is negative. Advantages are obtained for all nineteen complexes. Disaggregation of the advantage sums, however, reveals that Puerto Rico has a marked advantage for textile labor and marked disadvantages for almost everything else.

(5). Locational advantages are computed for "short" synthetic fiber complexes by reducing the number of component processes on the assumption that some inputs are imported rather than produced. The advantages for the short complexes are uniformly larger than those for the corresponding full complexes.

(6). The preceding locational advantages are corrected for differences between Puerto Rico and the mainland with regard to differences of production organization, output scale and wage-rate differentials. Some of the short complexes maintain their advantages under a wide variety of assumptions.

This book is excellent in many respects. The emphasis upon filling empty boxes with quantitative information is very refreshing. The author's conversion of engineering data into a form usable for economic analysis provides an excellent guide for subsequent studies. The computation of price differentials is handled with imagination and skill. The

use of the imponderables, judgment and economic intuition, is on the very high level characteristic of past works by Isard and his associates.

The major defects of the book are its lack of an underlying conceptual framework and a clear statement of goals. Most of these difficulties could be avoided if the authors would place their analysis within a programming format. A formal and exact statement would be of great aid even though it might prove necessary to use an *ad hoc* and inexact solution method because of the nonlinearities introduced by labor and capital costs.

Since the authors have assumed proportionality, divisibility and additivity, the production processes are easily placed within a programming format. The specification of meaningful constraints, i.e., inequalities, presents more difficult problems.

The authors' rejection of "linear" programming on the basis that "resource limitations . . . would not particularly influence the growth of those industries for which Puerto Rico might possibly have advantage" (p. 26) is hardly justified. There are many types of constraints other than resource limitations, e.g., minimum process levels and maximum sales levels. The authors themselves place a number of miscellaneous constraints upon the complexes (see pp. 62-68). Furthermore, it is very difficult for the reviewer to believe that resource limitations are of no importance.

The specification of an objective function would allow a clear statement of what the authors are trying to accomplish. Their analysis suggests that they desire to discover those complexes with the greatest monetary advantages for the arbitrarily specified operation levels. The complexes are comparable, however, only in that each is tied to a refinery input of 9.428 million barrels of crude per year and/or a synthetic fiber output of 36.5 million pounds per year. These physical specifications do not make the various alternative complexes comparable in economic terms.

The problems involved in selecting the particular processes to be included in "optimal" complexes and those involved in comparing full and short complexes would be greatly simplified by a programming analysis.

JAMES M. HENDERSON

University of Minnesota

Elementary Mathematics of Linear Programming and Game Theory, Edward G. Bennion. East Lansing: Bureau of Business and Economic Research, 1960. Pp. xvi, 140. $5.00.

With the advent and ensuing rapid growth in importance of linear programming, it was almost inevitable that a large number of books be

written to meet the demands of various segments of an expanding market. It was not inevitable, however, that we find many of these books filling the needs of a specified market as well as this one does.

This particular volume is for the "mathematically unsophisticated." (The author makes this abundantly clear by mentioning "mathematically unsophisticated" at least seven times in the introduction and first three pages of Chapter I.) The objective of the book is to impart an understanding of the mathematical rationale underlying linear programming and game theory to this segment of the market.

An oil refining problem is introduced to show the general nature of linear programming in an empirical context. The problem is then generalized and placed in mathematical notation. As a prelude to consideration of systems of equations having more unknowns than equations, Bennion reviews, in terms of analytical geometry, the meaning of a solution to a system of N equations in N unknowns. At this point the reader gains an impression of what the author means by "mathematically unsophisticated." Good courses in college algebra and analytic geometry represent the starting point for this book. Visualization of the linear programming problem in three-dimensional diagrams gives insight that might be missed by blindly following a cook-book simplex procedure.

It is not surprising that in order to explain the rationale of the simplex method effectively, Bennion finds it necessary to introduce an elementary treatment of some of the rules of matrix algebra. The duality aspects are treated from a mathematical viewpoint so that the transition to an exposition of game theory seems natural. It is, of course, outside the author's chosen province to deal with the economic interpretation of the linear programming dual.

In a final chapter, the author points out that while the businessman tends to view these techniques as aids to decision making, the academic economist is more interested in the properties of an optimal solution. It seems strange that Bennion chose general-equilibrium theory as an illustration of the relationship between linear programming and economic analysis. It would seem that the case of the static theory of the firm might have permitted a closer integration with the example presented at the outset of the book.

This little volume admirably meets its objective of giving the reader an understandig of the logic of linear programming and game theory. Since the explanation proceeds via mathematics and does not draw upon the extant body of economic theory that most agricultural economists possess, many in our profession may find more convenient ports-of-entry. Still to be recommended is the standard work of Dorfman, Samuelson, and Solow, *Linear Programming and Economic Analysis*, to provide a

connecting link between the familiar economic concepts and the rationale of linear programming and game theory, coupled with Heady and Candler's *Linear Programming Methods* to show computational procedures and to aid in model formulation.

We should look forward to the day when the need for such books as Bennion's will be diminished due to the effectiveness of the efforts which are now being exerted to include more formal mathematics in the various levels of our educational system. But this volume is a useful book for the group who lacked the foresight to take mathematics in their formal training and now wish to choose the first of the following alternatives: ". . . to roll up [their] sleeves and sweat a bit in the interests of self-education, or to risk withering slowly on the vine." (Preface, p. x.)

EARL R. SWANSON

University of Illinois

Benefit-Cost Analysis and Water Pollution Control, R. J. Hammond. Stanford: Food Research Institute, Stanford University, 1960. Pp. xiii, 95. $1.00.

Since the passage of the Flood Control Act of 1936, with the proviso that a project is justified ". . . if the benefits to whomsoever they may accrue are in excess of the estimated costs . . .," there have been a number of attempts, including a few ingenious ones, to put a price tag on intangibles.[1] In a Food Research Institute publication, R. J. Hammond rejects this approach (p. 34) as being second best for water pollution control projects and concludes (p. 69) that "water-pollution control projects, as a class, do not lend themselves to benefit-cost analysis."

The intangible nature of pollution abatement benefits and the difficulty in measuring costs are cited as reasons for this negative attitude (p. 69), but one gathers the impression that the real reason is the discovery that many pollution-control projects could not possibly be justified on economic grounds (pp. x and 57-69).

Hammond is quite critical of benefit-cost analysis as it applies to projects other than those for pollution control; if his recommendations were adopted, agencies administering these projects would find it more difficult to come up with favorable benefit-cost ratios. Why sewage-

[1] For interesting work along these lines, see: Marion Clawson, "Methods of Measuring the Demand for and Value of Outdoor Recreation" (Washington, D.C.: Resources for the Future, Inc., 1959), 36p. (RFR Reprint Ser. 10.); Earl M. Campbell, *Toll Bridge Influence on Highway Traffic Operation* (New Haven: Bu. of Highway Traffic, Yale Univ., 1947), pp. 43-44; G. P. St. Clair and Nathan Lieder, "Evaluation of the Unit Cost of Time and of the Strain and Discomfort Cost of Non-Uniform Driving," paper prep. for Workship Conf. on Economic Analysis in Highway Programming, Location and Design, Natl. Acad. Sci., Washington, D.C., Sept. 18, 1959, pp. 1-29.

treatment plants should be exempted from efficiency considerations and other water-resource projects subjected to even stricter benefit-cost analysis is not clear.

The main arguments presented for neglecting efficiency considerations in justifying pollution-control projects seem to be: (1) The costs are not onerous compared with other items of municipal expenditure (pp. 49-50); and (2) water may be underpriced and, therefore, it is rational to welcome any measure that increases its price (p. 74). Neither argument is above suspicion.

The capital cost of providing full sewage treatment for all domestic wastes in 1952 would, on the average, have exceeded the book value of plant and equipment used to provide elementary and secondary education.[2] It might be noted in this connection that voters in California in 1958-59 defeated 32 per cent of all school bond issues. Apparently, even school buildings can be considered "onerous."

While water may be underpriced in arid areas, it is not clear that enforcement of pollution-control standards would raise the price of water in all instances or that water users can be made better off by dissipating the consumer and producer surpluses associated with a limited supply of water in the construction of uneconomic pollution-control projects.[3]

The waste disposal problem, it seems to me, is in many respects ideally suited to economic analysis. To begin with, the social cost of ordinary pollution is discontinuous and need be considered only at critical points. Most important are (1) the point at which the dissolved oxygen in the receiving water is reduced below four parts per million, causing fish to suffocate, with a consequent loss of recreational benefits, and (2) the point at which dissolved oxygen is reduced to zero, causing anerobic decay to commence, accompanied by malodorous conditions. While an economist might not be able confidently to assign a dollar value to the social cost of pollution at these points, he certainly should be able to gather information with respect to the fish kill that might result and the number of people downstream who would be affected, which would aid the pollution-control authority in rendering a decision as to how much pollution to permit.

Once a decision is reached as to the standard to enforce—in general,

[2] The *Biennial Survey of Education* puts the value of public elementary and secondary school property at $14 billion in 1951-52. If Schwob's estimate of $110 per capita for full sewage treatment (cited by Hammond, p. 50) is multiplied by the 1951 population residing in the United States, a figure approaching $17 billion is obtained.

[3] In many communities, a significant portion of the cost of providing both water and sewage treatment is paid for from general tax revenues rather than user charges; the relationship between price and cost is further obscured by the willingness of Congress in recent years to underwrite part of the cost of constructing sewage-treatment facilities.

the choice is between a fish-kill standard, a nuisance standard, and no standard at all—many opportunities for economizing are likely to exist.

In the first place, the technology of waste treatment is such that only sizeable increments in treatment facilities need be considered. (Primary sewage treatment reduces the biochemical oxygen demand of ordinary municipal effluent by about 35 per cent, secondary treatment reduces the amount of organic matter another 30 per cent, while full treatment will bring the total reduction up to about 95 per cent.) Second, with respect to any of these treatment programs, there is convincing evidence as to economies of scale.[4]

Aside from the problem of determining at each outfall the degree of treatment that will minimize the total cost of waste treatment, there are obvious interdependencies and opportunities for cooperative action on the part of affected parties to increase the purification capacity of receiving waters through algae control, low-flow regulation, and addition of oxygen to receiving waters.

Hammond's analysis is studded with examples (see pp. 47-48) in which cost-sharing arrangements between cities would lead to a more economical solution to the pollution-control problem. In view of the recognized opportunity to apply elementary notions of efficiency to a problem of increasing importance and to create institutional devices for obtaining pollution control at a smaller cost, it is difficult to understand Hammond's disregard for economizing.

Part of the explanation may lie in his unqualified acceptance of the program authorized by the Federal Water Pollution Act, which he interprets as "an all-out attack on water pollution . . . on a predetermined plan allocating shares to the respective communities." In Hammond's words (p. 62), this program is "*ipso facto* contrary to the notion of the most efficient use of resources embodied in benefit-cost analysis."

Disregarding the bias that is perhaps inevitable in a work of this kind, there is a sense in which the essay is a contribution. Foremost, it raises the fundamental question of whether economists ought to be in the business of rendering as many value judgments as are implied in determining ". . . if the benefits to whomsoever they may accrue are in excess of the estimated costs. . . ." A mistake too often made, it seems to this reviewer, is to assume that to be meaningful a benefit-cost ratio must be reduced to dollars per dollar. In many instances, the ratio of physical output, population affected, or visits per dollar of costs would be equally as use-

[4] C. J. Velz, "How Much Should Sewage Treatment Cost?" *Engineering News Record,* 141:84-86 Oct. 14, 1948; D. H. Howells and D. P. Dubois, "Design Practices and Costs for Small Secondary Sewage Treatment Plants in the Upper Midwest," *Sewage Works,* 30:1327-35, Nov. 1958; and Gordon E. Man, "Sewage Treatment Plant Costs in Kansas," *Sewage Works,* 30: 1443-53, Dec. 1958.

ful in rendering a decision and not nearly as misleading as some benefit-cost calculations. So long as multiple outputs accrue in more or less fixed proportions, and prices, interest rates, and depreciation factors can be assumed to be about the same for all projects considered (these are not unreasonable assumptions as far as conventional pollution control projects are concerned), it doesn't really matter, from the viewpoint of cost minimizing, whether or not physical outputs are assigned a dollar value.

Considering the uncertainty that exists in the real world and the disagreement that exists among economists over such matters as the appropriate rate of discount and whether or not secondary benefits should be included in the analysis, it is questionable whether benefits and costs should be reduced to a unique numerical value. By restricting the number of comparisons that are made and by obscuring the cost per salient unit of output, the pricing of project outputs could serve more to bias Congressional decision making than to improve welfare. In categorically denying the relevance of benefit-cost analysis, as it pertains to pollution control, Hammond's essay may spark a reappraisal of the role economists ought to perform in project evaluation. In any event, *Benefit-Cost Analysis and Water-Pollution Control* is interesting reading and provides food for thought.

EDWARD F. RENSHAW[5]

University of California
and
Agricultural Research Service

[5] The opinions expressed in this paper are those of the author and do not necessarily represent the views of the Farm Economics Research Division, Agricultural Research Service, or the U. S. Department of Agriculture.

NEWS NOTES

D. E. ALLEGER has returned to his position as Associate Agricultural Economist in the Florida Agricultural Experiment Station after serving four years as Agricultural Economist and Chief of Party of the University of Florida Agricultural Mission to Costa Rica.

M. E. ANDAL, Economics Division, Canada Department of Agriculture, was advisor to the Canadian Government Delegation at the 1960 International Labor Conference in Geneva, Switzerland.

NORRIS ANDERSON, formerly with Greeley National Bank, Greeley, Colorado, has joined the staff at South Dakota State College.

WALTON J. ANDERSON, Chairman of the Department of Agricultural Economics, University of British Columbia, is President of the Agricultural Institute of Canada for 1960-61.

W. W. ARMENTROUT, relinquished his duties as Head, Department of Agricultural Economics and Rural Sociology at West Virginia University, effective June 30. He will continue his duties as Professor of Agricultural Economics and as Agricultural Economist for the West Virgina Agricultural Experiment Station.

LUDWIG AUER has been appointed Research Associate in the Department of Economics and Sociology at Iowa State University (Ames).

KENNETH L. BACHMAN, formerly Assistant Director, Farm Economics Research Division, ARS, transferred on September 1 to the Agricultural Marketing Service, where he is assistant to the Deputy Administrator for Economics and Statistics.

GEORGE L. BAKER, JR., formerly on the staff at Purdue University, has completed the requirements for the Ph.D. degree and has accepted a position with the Department of Marketing, University of Southern California.

CLARE A. BECKER returned to Pennsylvania State University on August 10 following a six-month sabbatical leave with the Marketing Economics Research Division, AMS.

ROBERT D. BELL, formerly of South Dakota State College, is spending a year on the staff at Purdue University for special research in resource use with Prof. Vernon W. Ruttan.

J. HOMER BLACKSTONE, Agricultural Economist at Auburn University, is currently serving as an Agricultural Economics Consultant with the U. S. Study Commission, Southeast River Basins, in Atlanta, Georgia.

MELVIN G. BLASE, of the Farm Economics Research Division, ARS, is on military furlough through June 30, 1963.

CURTIS BRASCHLER, who recently completed his Ph.D. at Purdue University, has joined the University of Missouri staff as Assistant Professor of Agricultural Economics.

C. A. BRATTON has returned to Cornell University after devoting the academic year 1959-60 to lectures and research under a Fulbright award at the Institute of Farm Accounting, Kyoto University, Japan.

V. JOHN BRENSIKE, Marketing Economics Research Division, AMS, recently toured Russia as chairman of a technical committee representing the United States grain industry. The committee studied grain handling, storage and processing in the Soviet Union. Other United States representatives included John C. Cowan, Dannon Mills; Roy K. Durham, Technical Consultant; Eugene T. Olson and Raymond Vickery, Foreign Agricultural Service; Leo E. Holman and Lawrence Zeleny, AMS.

DURWARD BREWER, who recently completed his Ph.D. at the University of Missouri, has been appointed Assistant Professor of Agricultural Economics there.

EMER E. BROADBENT has been promoted to the rank of Professor at the University of Illinois.

RAY F. BROKKEN has been appointed Collaborator with the Farm Economics Research Division, USDA. He is stationed in the Department of Economics and Sociology at Iowa State University (Ames), where he is also continuing his graduate work.

ALLEN J. BROWN, who recently received the M.S. degree from Auburn University, has been appointed Extension Poultry Marketing Specialist there.

C. HAROLD BROWN, who recently completed the requirements for the Ph.D. at Pennsylvania State University, has joined the Department of Agricultural Economics and Sociology of the Agricultural and Mechanical College of Texas as Assistant Professor. He will teach Sociology.

CHARLES W. BROWN has joined the Department of Agricultural Economics and Sociology of the Agricultural and Mechanical College of Texas as Assistant Professor for Grain Marketing Research.

CARROLL G. BRUNTHAVER, Ohio State University, resigned August 31 to accept appointment as temporary assistant professor at Michigan State University, replacing Harold Riley, now in Columbia.

MARGUERITE C. BURK has transferred from the Agricultural Economics Division to the Basic Research Group, Marketing Economics Research Division, AMS. She is spending the fall quarter at the University of Minnesota Agricultural Economics Department, where she is giving courses in consumption economics.

WILLIAM N. CAPENER has resigned as an Assistant Professor in the Department of Economics and Sociology at Colorado State University to accept a position with the Marketing Economic Research Division, AMS. He will continue to reside in Fort Collins and to conduct research in livestock marketing.

REYNOLD E. CARLSON, Vanderbilt University, spent several weeks last March and April as consultant to the Ford Foundation in Brazil, where he studied the status of economic research for the Foundation.

LON C. CESAL has been appointed Research Associate in the Department of Economics and Sociology at Iowa State University (Ames).

J. B. CLAAR has been appointed Associate Director of the Illinois Agricultural Extension Service. He was formerly with the Federal Extension Service.

J. W. CLARKE, formerly Director of the Vocational School at Kindersley, Saskatchewan, has been appointed Secretary and Treasurer of the Winnipeg Grain Exchange.

JAMES H. CLARKE was promoted to Professor, Department of Agricultural Economics and Rural Sociology, West Virgina University, effective July 1.

WILLARD W. COCHRANE has been on leave from the University of Minnesota serving as Agricultural Advisor to Senator John F. Kennedy.

LINDON COCKROFT, who completed his Ph.D. work at North Carolina, joined the staff of the University of Arizona on September 1. He will teach and conduct research in marketing.

C. D. COVEY has resigned as Assistant Agricultural Economist in the Florida Agricultural Experiment Station to pursue graduate study at Louisiana State University.

CHARLES L. CRAMER, who recently completed his Ph.D. at the University of

Missouri, has been appointed Assistant Professor of Agricultural Economics there.

CLYAS L. CRENSHAW, formerly Assistant Agricultural Economist with the Florida Agricultural Experiment Station, is now with the Agricultural Estimates Division, Agricultural Marketing Service, USDA, stationed at the Montgomery, Alabama, field office.

DALE DAHL has been appointed Instructor in Agricultural Economics at the University of Minnesota.

RICHARD T. DAILEY, formerly with the Washington, D.C., staff of the Farm Economics Research Division, ARS, transferred to the University Park, Pa., office in June.

IRVING F. DAVIS, JR., has resigned from the Department of Economics and Sociology at Colorado State University to accept a position in the Division of Business at Fresno State College, Fresno, California.

JOHN A. DAWSON, formerly with the Economics Division, Canada Department of Agriculture, has been appointed Economist to the Board of Broadcast Governors, Ottawa. Dr. Dawson formerly served as Secretary to the Royal Commission on Price Spreads.

RAYMOND DIETRICH, Marketing Economics Research Division, AMS, has transferred from Washington, D.C., to the Oklahoma State University field office at Stillwater.

LOUIS V. DIXON, formerly with AMS, has accepted a position as Associate Professor in the Department of Economics at Mississippi Southern College.

GORDON J. DOBSON, Economics Division, Canada Department of Agriculture, attended the 16th session of GATT in Geneva, Switzerland.

W. M. DRUMMOND, formerly with the Royal Commission on Price Spreads, Ottawa, has been appointed Economic Advisor to the Agricultural Stabilization Board, Canada Department of Agriculture, Ottawa.

WALTER H. EBLING retired in July from his position with the Agricultural Estimates Division, AMS, after more than 33 years service. He was appointed Statistician-in-Charge of the Madison, Wisconsin, office in 1927. In 1951 he received a USDA Distinguished Service Award in connection with this work. Walt is continuing on the staff of the Agricultural Economics Department at the University of Wisconsin, where he has taught Agricultural Statistics for 25 years, and has more recently been assisting the Dean of Agriculture in work with foreign students.

J. C. EILAND has transferred from the Grain Branch of Farmer Cooperative Service to the Feeds and Grain Section of the Marketing Economics Research Division, AMS.

VERN ELEFSON has accepted a position as assistant professor in agriculture at River Falls State College. He was formerly instructor in agricultural economics at the University of Minnesota.

EVERETT ELWOOD is on sabbatic leave from Michigan State University for the academic year 1960-61. He will spend most of it in study at California.

HOMER C. EVANS was promoted to Head, Department of Agricultural Economics and Rural Sociology at West Virginia University, effective July 1.

WILLIAM A. FAUGHT, Marketing Economics Research Division, AMS, is spending the academic year taking post-doctoral work at Harvard University.

CLARKE H. FERRIES is now a Farm Management Specialist with the Extension Branch of the Alberta Department of Agriculture.

JOHN FERRIS has been promoted to Assistant Professor at Michigan State University.

C. JOHN FLIGINGER, Agricultural Estimates Division, AMS, transferred in June from the Office of the State Statistician at Columbus, Ohio, to the Washington, D.C., office, Fruit and Vegetable Statistics Branch.

IAN F. FURNISS, formerly with the Research Branch, Canada Department of Agriculture, has joined the Production Economics Section of the Economics Division of the Department at Ottawa.

JOHN F. GALE joined the staff of the Farm Economics Research Division, ARS, in August. He will carry on research in farm real estate values.

H. PRENTISS GAZAWAY, who formerly headed the Department of Agricultural Economics, University of Alaska at Palmer, has joined the Marketing Economics Research Division, AMS.

JAMES GOERING accepted a position as Research Associate, Michigan State University, effective September 1. He is being assigned to Columbia, to assist in the University's project there, giving special attention to research on how surplus disposal affects agricultural and economic development.

MILTON E. GRIFFING joined the Lincoln, Nebraska, staff of the Farm Economics Research Division, ARS, in July. He will work on problems of land and water research.

ERNEST W. GROVE, formerly head of the Farm Income Estimates Section, Farm Income Branch, AMS, transferred to the Commodity Stabilization Service on September 4.

HERMAN M. HAAG, Southern Illinois University, is serving as Acting Dean of the School of Agriculture during the absence of W. E. Keepper.

THORLAND R. HALL of the Fruit and Vegetable Statistics Branch, Agricultural Estimates Division, AMS, retired on August 31 after almost 37 years of service.

ALBERT N. HALTER, formerly of the University of Kentucky, joined the staff of Oregon State College as Associate Professor of Agricultural Economics, effective September 1. He will teach and conduct research in Production Economics and Farm Management.

WILFRIED HAMMER, Economist with the Max Planck Institute, Germany, is spending one year on the staff at Purdue University for special research in connection with the Purdue University cardiac project under the supervision of Prof. W. H. M. Morris.

RAYMOND R. HANCOCK, Agricultural Estimates Division, AMS, transferred in July from the Office of State Statistician at Athens, Georgia, to the Office at Orlando, Florida.

ERNEST HARDY has resigned his position as Research Associate to resume graduate studies at Cornell University.

WILLIAM E. HAVILAND is serving as Director of Research for the Ontario Agriculture Enquiry Committee.

JOSEPH C. HEADLEY joined the University of Illinois staff on September 15 as Assistant Professor of Farm Management. He was formerly with the University of California at Davis.

WALTER G. HEID, who recently received his M.S. at the University of Missouri, has joined the Marketing Economics Research Division, AMS.

PETER HELMBERGER was appointed Assistant Professor of Agricultural Economics at Pennsylvania State University, effective September 1. He had previously been engaged in graduate study at the University of California.

JOHN H. HERBST has been promoted to the rank of Associate Professor at the University of Illinois.

STEPHEN HIEMSTRA, Marketing Economics Research Division, AMS, formerly stationed at Berkeley, California, is now on the staff at Washington, D. C.

JOHN R. HILDEBRAND has resigned from Kansas State University to accept appointment as Agricultural Economist with International Development Services, Inc. He is located in Guatemala, participating in provision of technical assistance for the Rural Economic Development program there.

CLIFFORD HILDRETH now has a joint appointment with the Departments of Economics and Agricultural Economics at Michigan State University. He continues as Editor of the *Journal of the American Statistical Association.*

RAY HOGLAND, Michigan State University, is on sabbatic leave for July-December, for study and travel in Europe.

ESTEL HUDSON, University of Missouri, has been appointed Instructor of Agricultural Economics.

S. CLAUDE HUDSON is now Executive Secretary, International Wheat Council, with headquarters in London, England. He was formerly Chief, Grain Division, Department of Trade and Commerce, Ottawa.

MERYL R. HUNT, Agricultural Estimates Division, AMS, transferred in August from the Office of State Statistician at Boise, Idaho, to the office at Sacramento, California.

JACK ISHIDA recently completed requirements for the Ph.D. degree at Purdue University and has returned to his position as agricultural economist at the University of Hawaii.

ELMAR JARVESOO, of the University of Massachusetts, is spending a sabbatical year in residence at North Carolina State College.

ALLEN O. JOHNSON is Research Associate in the Agricultural Industries Program of the Graduate School of Business and Public Administration at Cornell University.

STANLEY S. JOHNSON joined the Agricultural Adjustments staff of the Farm Economics Research Division, ARS, in July, and is stationed at Davis, Calif.

WILLIAM H. KASTENS, Agricultural Estimates Division, AMS, transferred in July from the Office of State Statistician at Topeka, Kansas, to the office at Columbus, Ohio.

MIGAKU KAWAMURA and ISUO TERADA, Professors at Hokkaido University, are spending a year of residence in the Department of Agricultural Economics, University of Massachusetts.

W. E. KEEPPER, Southern Illinois University, is on two-year leave of absence with FAO in Rome, working on a new educational program.

CHARLES E. KELLOGG, Assistant Administrator for Soil Survey, the Soil Conservation Service, USDA, received on July 29 an honorary degree of Doctor of Science from the Institut Agronomique de l'Etat at Gembloux (Belgium), on the occasion of the 100th anniversary of the founding of the Institute.

ELMER R. KIEHL, formerly Chairman of Agricultural Economics, University of Missouri, was appointed Dean and Director of the College of Agriculture and Experiment Station, effective September 1.

IVAN KINNE has completed graduate work at Cornell and is now Research Economist at the Battelle Memorial Institute in Columbus, Ohio.

EUNICE M. KNAPP, Analytical Statistician, AMS, has transferred from the Marketing Economics Research Division to the Statistical Standards Division.

EDWARD KOENIG recently returned from Nigeria, where he was with the International Development Services, Inc. He was a member of a team studying agricultural cooperatives and credit problems in Western Nigeria for the International Cooperation Administration. He had previously been for ten years the agent in New York State for the Baron De Hirsch Fund. He still resides in Kerhonkson, New York.

BALDUR H. KRISTJANSON, formerly of the Economics Division, Canada Department of Agriculture, Ottawa, is now with the Department of Northern Affairs and National Resources. He is serving as Secretary on the Resources for Tomorrow Conference.

L. BURBANK KRISTJANSON has been appointed Assistant Deputy Minister of Agriculture for the Province of Manitoba.

SOL KUTHROFF joined the staff of the Farm Economics Research Division, ARS, in August. He will work as a geographer in the Land and Water Research Branch.

MERRITT LAPLANTE, who finished his Masters program at the University of Massachusetts in August, will continue his studies at Texas A and M.

ROBERT E. LAUBIS, who recently received the Ph.D. from Ohio State University, has joined the Marketing Economics Research Division, AMS.

JERRY LAW returned to Louisiana State University in September after a two month lecture tour at the University of Hokkaido in Japan. He was promoted to Associate Professor July 1st.

H. KEITH LECKIE has been appointed Managing Director of the Meat Packers Council of Canada. Mr. Leckie first joined the Council in 1951 as Director of the Information Service.

DEANE LEE has been promoted to Assistant Professor at the University of Massachusetts.

RICHARD C. LINDBERG, formerly with the Farm Economics Research Division, ARS, where he developed a method of estimating fertilizer use levels to equalize returns to all inputs in crop production, has transferred to the Marketing Economics Research Division, AMS.

ADRIAN H. LINDSEY, retired head of the Department of Agricultural Economics, University of Massachusetts, has returned to Amherst after teaching for one year at Willamette College, Salem, Oregon.

SIEPKO H. LOK, formerly of the Economics Division, Canada Department of Agriculture, has been appointed Economic Development Officer with the Indian Affairs Branch, Department of Citizenship and Immigration, Ottawa.

RICHARD LONG has resigned from the Marketing Economics Research Division, AMS, and is now associated with the Extension Service of the University of Georgia.

CLOY P. LYLE, formerly with the Raleigh, N.C., staff of the Farm Economics Research Division, ARS, transferred to the Atlanta, Ga., office in June.

MURRAY A. MACGREGOR has been promoted to the rank of Professor in the Department of Agricultural Economics, Ontario Agricultural College.

CARL C. MALONE, Professor of Economics at Iowa State University (Ames), is spending August through June in India, where he is assisting the Ford Foundation with a program for increasing food production.

LLOYD C. MARTIN, Marketing Economics Research Division, AMS, is spending the current academic year at North Carolina State College, Raleigh. He will be taking course work for the Ph.D. degree.

WILLIAM MARTIN, who is completing the requirements for the Ph.D. at the University of California, will join the staff of the University of Arizona as Assistant Agricultural Economist in December. He will teach and conduct research in production economics.

HENRY MARTINEAU, who completed his Masters program at the University of Massachusetts in June, is now employed with the Connecticut Milk Producers Association.

RUSSELL F. MCDONALD, Instructor, Department of Agricultural Economics and Rural Sociology, Ohio State University, resigned August 31 and is now at Michigan State University.

J. WENDELL MCKINSEY was elevated to Chairman of the Department of Agricultural Economics at the University of Missouri, effective September 1.

BENNY R. MCMANUS, formerly employed by the Alabama Agricultural Extension Service, has accepted an appointment as Assistant in Agricultural Economics at Auburn University.

TERNON MCMINIMY has resigned as research assistant in the Kansas Agricultural Experiment Station to continue Ph.D. study. He will have an assistantship at the University of California at Berkeley.

GENE MCMURTRY, formerly on the staff at Purdue University, has joined the staff of Virginia Polytechnic Institute to work in farm management and agricultural policy.

JOHN W. MELLOR has returned to Cornell University from an 18-month study of the Indian agricultural economy and related current research and teaching activities. He was sponsored by the Council on Economic and Cultural Affairs.

ALONZO METCALF has joined the University of Missouri staff as Instructor in Agricultural Economics after returning from Denmark, where he was studying under a Fulbright Scholarship.

HOMER B. METZGER, of the University of Maine, has been granted a sabbatical leave of absence for 1960-61 to accept a Fulbright award as lecturer in the Netherlands.

GEORGE MONTGOMERY has resigned the headship of the Departments of Agricultural Economics and of Economics and Sociology at Kansas State University. He will continue to hold the rank of Professor of Agricultural Econimics. He began on July 1 a second consecutive 2-year tour as group leader in the KSU-ICA-India project with headquarters at Osmania University, Hyderabad.

LEO J. MORAN has resigned as Assistant Agricultural Economist at the University of Arizona to accept a position as economist with the Stanford Research Institute at South Pasadena, California.

ERNEST J. NESIUS, formerly Associate Director of Agricultural Extension at the University of Kentucky, became Dean of the College of Agriculture, Forestry, and Home Economics at West Virginia University, effective July 1.

PAUL E. NESSELROAD, Assistant Agricultural Economist in the Department of Agricultural Economics at West Virginia University, will be on leave during the 1960-61 academic year to pursue work toward the Ph.D. degree at the Pennsylvania State University.

WILLIAM H. NICHOLLS, Vanderbilt University, spent the summer of 1960 as a consultant to the Ford Foundation in Brazil, where he surveyed faculties of economics and agricultural economics.

HAROLD L. NIX recently resigned as Assistant Rural Sociologist at Auburn University to accept a similar position at Georgia State College.

TERRY N. NORMAN, formerly with the Marketing Economics Research Division, AMS, has resigned to accept employment with a private organization.

ROBERT E. OLSON, Marketing Economics Research Division, AMS, formerly stationed at Berkeley, California, as Secretary, Western Agricultural Research Council, has transferred to Washington, D.C. He is now head of the Marketing Information and Statistics Section of the Division.

DONALD G. PARIS joined the staff of the University of Tennessee on August 1 as Assistant Agricultural Economist, after completing his Ph.D. work at the University of Kentucky.

CECIL V. PARKER, Director Agriculture Division, Dominion Bureau of Statistics, has been elected a Fellow of the Agricultural Institute of Canada.

FREDERICK A. PERKINS, formerly Instructor in Fruit Marketing at the University of Maine, has accepted a position in the Agricultural Economics Department at Rutgers University.

RICHARD PHILLIPS, Professor of Economics at Iowa State University (Ames), is spending September through December in Nigeria on a special assignment with the International Cooperation Administration.

C. V. PLATH, Associate Professor of Agricultural Economics at Oregon State College, has taken a one year leave of absence to accept a position with the Food and Agriculture Organization in Mexico City. Dr. Plath started his work on September 1 on a land use survey of a number of Central American countries.

LOUIS A. PLOCH, of the University of Maine, was a group leader on a "People to People" tour during the month of August, visiting the Netherlands, Belgium, Poland, Czechoslovakia and Russia.

LEONIDUS POLOPOLUS has been appointed Assistant Professor in the Department of Agricultural Economics at Louisiana State University. Dr. Polopolus did his graduate work at the University of California. He will teach and do research in Farm Management and Production Economics at Louisiana State University.

PAUL C. POWNALL, Agricultural Estimates Division, AMS, transferred in July from the Office of State Statistician at Cheyenne, Wyoming, to be Statistician in Charge of the new field office at Palmer, Alaska. Alaska is the 43rd State to enter into cooperation with USDA on crop reporting.

PHILIP M. RAUP is on a year's sabbatical leave from the University of Minnesota. He will spend the major part of the leave studying land tenure at FAO in Rome and at Cambridge University in England.

EWART P. REID has been appointed Chief of the Marketing Section, Economics Division, Canada Department of Agriculture, succeeding A. H. Turner.

L. A. REUSS assumed his duties as Agricultural Economist with the Agricultural Research Service, USDA, in July after serving a year as Land Economist with the University of Florida Agricultural Mission to Costa Rica.

V. JAMES RHODES, University of Missouri, is spending his sabbatical year, August-June, with the Basic Research Group, Marketing Economics Research Division, AMS, in Washington.

A. E. RICHARDS, Economics Division, Canada Department of Agriculture, is a

member of the Canadian Delegation to GATT meetings in Geneva, Switzerland.

ROBERT L. RIZEK, USDA Regional Marketing Coordinator, was stationed in the Department of Economics and Sociology at Iowa State University (Ames) starting September 1.

T. J. RUTHERFORD has been appointed Chairman of the Farm Credit Corporation, Ottawa.

FREDERIC O. SARGENT, formerly of Texas Agricultural and Mechanical College, has been appointed an Associate Professor in charge of Land Economics in the Department of Agricultural Economics, Ontario Agricultural College.

C. F. SARLE returned to his position as Professor of Agricultural Economics at the University of Florida in June after serving for one year as Agricultural Census Expert with the Food and Agriculture Organization of the United Nations with headquarters in Bangkok, Thailand.

ROBERT W. SCHOEFF has resigned his position as manager of market research for Central Soya Inc., Fort Wayne, Ind., and has accepted a position with Kansas State University as Associate Professor and Extension Specialist in Formula Feeds. He will be leader of a pilot formula feed extension project that has been initiated in cooperation with the Federal Extension Service. The objective is to plan and conduct a pilot educational program designed to assist personnel in the formula feed industry in the adoption and use of latest feed formulation techniques, manufacturing processes and techniques, marketing methods, and modern management tools.

R. E. SELTZER became President of the Western Farm Economics Association at the August meeting of that Association in Palo Alto.

HARVEY SHAPIRO took up his duties as a fiscal and financial economist with the agricultural finance research staff of the Farm Economics Research Division, ARS, in July.

FRANK SHEFRIN, Economics Division, Canada Department of Agriculture was a member of the Canadian Delegation to the F.A.O. meetings in Rome.

VERNON M. SHEPPARD, JR., Extension Economist, Agricultural Extension Division, West Virginia University, was awarded an M. S. degree by Virginia Polytechnic Institute in June, 1960.

FAY M. SIMS has been promoted to the rank of Assistant Professor at the University of Illinois.

CAREY B. SINGLETON joined the staff of the Farm Economics Research Division, ARS, in July. He will carry on research in farm real estate values.

MELVIN D. SKOLD has been appointed Research Associate in the Department of Economics and Sociology at Iowa State University (Ames).

DUANE L. SORENSEN has been appointed Research Associate in the Department of Economics and Sociology at Iowa State University (Ames).

ROBERT G. SPITZE has joined the University of Illinois staff as Associate Professor of Agricultural Economics. He was formerly at the University of Tennessee.

MILTON STEINMUELLER, formerly with ARS at Pullman, Washington, accepted an assistant professorship in the Department of Resource Development at Michigan State University effective August 15. He will give teaching and research attention to consumption and rural economic development.

RANDALL STELLY and JAMES E. KIRBY of the Agricultural and Mechanical College of Texas have been in Europe since August on a contract research

project with the Foreign Agricultural Service, USDA, evaluating the effectiveness of market development projects undertaken by the USDA for cotton, wheat, feed grain, soy beans, soy bean products, and poultry. They will return in December.

GEORGE W. STOCKING, Vanderbilt University, has been assigned to the American University of Beirut, Lebanon, for a year beginning last September, under the University's Overseas Professorship Program.

GARY SULLIVAN and THOMAS TOWNSEND have been appointed Research Assistants in Economics for the Kansas Agricultural Experiment Station, Kansas State University.

CHESTER SWANK has joined the Division of Agricultural Economics Programs, Federal Extension Service, as marketing economist with responsibility in the area of consumer marketing economics. Mr. Swank has been employed in consumer marketing information programs of the Ohio State Extension Service.

ANTHONY M. TANG, Vanderbilt University, was recently promoted to Associate Professor of Economics and Business Administration.

JOHN R. TEDFORD, formerly with the Agricultural Economics Branch of TVA, joined the University of Missouri staff October 1 as Assistant Professor of Agricultural Economics.

GEORGE E. TOBEN was promoted to Professor, Department of Agricultural Economics and Rural Sociology, West Virginia University, effective July 1.

NORMAN TOWNSHEND-ZELLNER, Marketing Economics Research Division, AMS, has transferred from the UCLA office to Washington, D.C., where he joins the Division's Basic Research Group.

GEORGE N. TUCKER, JR., Agricultural Estimates Division, AMS, transferred in June from the Office of State Statistician at Sacramento, California to the office at Madison, Wisconsin.

W. GLENN TUSSEY joined the staff of Federal Extension Service in the Division of Agricultural Economics Programs on March 20, 1960. Mr. Tussey had most recently been with the cotton standards and testing work of AMS, and prior to that was cotton marketing specialist with the North Carolina Extension Service.

HAVEN D. UMSTOTT, formerly with the Commodity Stabilization Service, USDA, has joined the staff of the Market Development Research Division, AMS, to work with the Market Potentials Research Branch.

L. T. WALLACE has completed the requirements for the Ph.D. degree and has been promoted to assistant professor at Purdue University.

FREDERICK V. WAUGH has received a Senior Research Award from the Social Science Research Council, to make a study of the agricultural surplus problem and what can be done about it. He is on leave from USDA for a year beginning last July.

CLARA WENDT, formerly consumer specialist at Purdue University, has accepted a similar position at Cornell University.

GEORGE WESTCOTT returns to his post at the University of Massachusetts in November after spending two years at Hokkaido University in Japan.

VIRGIL R. WERTZ retired from the Department of Agricultural Economics and Rural Sociology, Ohio State University, September 30.

STEPHEN F. WHITTED, who recently completed his Ph.D. at the University of Missouri, has been appointed Associate Professor of Agricultural Economics there.

D. F. WILKEN has been promoted to the rank of Associate Professor at the University of Illinois.

NORMAN WILSON, who recently completed his Ph.D. at the University of Missouri, has rejoined the Southern University New Orleans staff.

RAMON B. WILSON has been appointed Market Service Director at Purdue University to coordinate marketing service work at the University involving the various institutions of the state. Indiana has no State Department of Agriculture and many of the marketing functions usually under such an agency fall under the new position which Dr. Wilson will head. He will continue to carry some responsibilities in the Agricultural Economics Department.

LAWRENCE WITT completed his assignment with the Office of International Programs at Michigan State University on June 30 and returned to full time in the Department of Agricultural Economics.

KARL WRIGHT returned to East Lansing on August 1, following two years as Head of the Michigan State University project in Okinawa.

PHILIP A. WRIGHT, Ontario Agricultural College, spent the past summer at Michigan State University on a Canada Council grant.

OBITUARY

ROBERT S. ELLIOT, Secretary-Treasurer of the Winnipeg Grain Exchange, died in February, at the age of 49. He was a graduate of the University of California (1932), and was a pilot in the Royal Canadian Air Force during World War II. After the war he served, successively, as Director of the Manitoba Bureau of Industry and Commerce, Statistician with the Canadian Wheat Board, and Assistant to the President of the Winnipeg Grain Exchange. He became Secretary-Treasurer of the Exchange in 1957. An active member of the Canadian Agricultural Economics Society, he helped organize the series of annual Workshops conducted by the Society in recent years, played a leading role in managing the AFEA-CAES joint annual meeting at Winnipeg in 1958, and at the time of his death was a member of the Canadian Council for the International Association of Agricultural Economists.

J. P. MONTGOMERY, Associate Professor of Agricultural Economics at Louisiana State University and long time member of American Farm Economics Association died on July 25th. Mr. Montgomery was on a vacation trip in Kansas when he had a heart attack. He was 69 years old.

ORGANIZATIONAL ANNOUNCEMENTS

Attention is called to the Society for International Development, a professional organization of persons interested in the economic and social development of the less developed parts of the world. Persons of all professional backgrounds are welcomed to membership. Present membership exceeds 1,000 and includes persons from over 50 countries. Academic, government, international agency, and business organization employees are all included.

The importance of technical and economic assistance to the lower income countries is universally acknowledged. The Society is the first professional organization seeking to include all workers in this field in a single organization.

The Society publishes the *International Development Review*. Membership includes receipt of the *Review*.

Membership inquires should be addressed to: Marion Clawson, Executive Secretary, Room 408, 1145 19th St. N.W., Washington 6, D.C.

New officers of the Canadian Agricultural Economics Society for the year 1960-61 are: President, G. P. Boucher; Vice-Presidents, J. C. Gilson, S. H. Lane; Secretary, I. F. Furniss.

Other members of the Executive Council include: W. E. Haviland, Past President; P. J. Thair, Editor; J. W. Channon, Treasurer; and W. Darcovich, L. W. J. Hurd, B. H. Kristjanson and A. W. Wood.

The Center for Agricultural and Economic Adjustment, Iowa State University will initiate the first Annual Farm Policy Review on November 29 through December 1, 1960. The Conference will review goals and objectives of policy and analyze recent policy legislation accordingly. It is expected that this review will take place annually.

A European Productivity Agency team of 21 young professionals from 13 countries will spend the year 1960 at Michigan State University under the general sponsorship of the OEEC. They will study in the areas of livestock marketing, fruit and vegetable marketing, extension methods, statistics and agricultural data collection. Vernon Sorenson is advising on and developing their program.

Team reports of the foreign study project of the Federal Extension Service and Foreign Agricultural Service, USDA (see February "News Notes," page 218), will be published in the *Proceedings* of the 1960 National Policy Conference. Extension Public Affairs Specialists in each State have copies of individual country reports. Members of the three study teams were as follows:

European team (spring, 1959): Wallace E. Ogg, Iowa State University (Leader of team); T. E. Atkinson, University of Arkansas; S. Avery Bice, University of Colorado; Robert G. Cherry, Texas A and M College; Kenneth R. Farrell, University of California; C. E. Klingner, University of Missouri; L. H. Simerl, University of Illinois; Karl Shoemaker, FES; and Paul Quintus, FAS.

Far East team (winter, 1960): John Dunbar, Purdue University (Leader of team); Rupert B. Johnston, Mississippi State University; John W. Mamer, University of Connecticut; Arthur Mauch, Michigan State University; Everett E. Peterson, University of Nebraska; Luther J. Pickrel, University of Minnesota; Robert W. Wilcox, University of Idaho; Raymond C. Scott, FES; Quentin M. West, FAS.

Latin American team (spring, 1960): Raymond J. Penn, University of Wisconsin (Leader of team); Arthur J. Cagle, Washington State University; W. D. Curtis, Louisiana State University; Bennett A. Dominick, Jr., Cornell University; Riley S. Dougan, Ohio State University; Leon Michaelson, Utah State University; W. L. Turner, North Carolina State College; Karl Shoemaker, FES; Arthur Kevorkian, FAS.

WINTER PROGRAM OF THE AMERICAN FARM ECONOMICS ASSOCIATION JOINT SOCIAL SCIENCE ASSOCIATION MEETINGS

St. Louis, Missouri, December 27-30, 1960

Tuesday, December 27

8:00 P.M. Executive Committee Meeting

Wednesday, December 28

Morning Session (Joint with Econometric Society)

CONTRIBUTIONS OF ECONOMETRICS TO FARM PRICE AND INCOME POLICY

Chairman: KARL A. FOX, Iowa State University

Papers: Methods, Assumptions, and Results of the Price and Income Projections of the United States Department of Agriculture
C. KYLE RANDALL and ANTHONY S. ROJKO, United States Department of Agriculture

Methods, Assumptions, and Results of Free Market Projections for Livestock and Feed Economy
ARNOLD PAULSEN and DONALD R. KALDOR, Iowa State University

Free Market Price Projections Based on a Formal Econometric Model
WILLIAM A. CROMARTY, Connel and Company, and DALE E. HATHAWAY, Michigan State University

Discussants: HARLOW W. HALVORSON, University of Wisconsin
HAROLD F. BREIMYER, Council of Economic Advisers

Afternoon Session (Joint with Econometric Society)

LINEAR PROGRAMMING APPROACH TO THE SOLUTIONS OF PRACTICAL PROBLEMS IN FARM MANAGEMENT AND MICRO-AGRICULTURAL ECONOMICS

Chairman: GLENN L. JOHNSON, Michigan State University

Papers: Programmed Solutions to Practical Farm Problems
EARL R. SWANSON, University of Illinois

Shortcomings in Programmed Solutions to Practical Farm Problems
CLARK EDWARDS, Oklahoma State University

Prospective and Potential Improvements in Programming
GEORGE B. DANTZIG, The RAND Corporation

Discussants: DEAN E. MCKEE, Michigan State University
FREDERICK V. WAUGH, United States Department of Agriculture

Thursday, December 29

Morning Session

THE ROLE OF AGRICULTURE IN THE WORLD ECONOMY

Chairman: SHERWOOD O. BERG, University of Minnesota

Papers: Problems of Increasing Agricultural Productivity in Less Advanced Economies
JIMMYE S. HILLMAN, University of Arizona

Capital Investment Opportunities: Past and Present
LAWRENCE W. WITT and MAURICE F. PERKINS, Michigan State University

Discussants: WILLARD L. THORP, The Merrill Center for Economics, Amherst College
W. DAVID HOPPER, University of Chicago

Afternoon Session (Joint with American Economic Association)

WHEAT: A PERMANENT NEED FOR A FARM PROGRAM?

Chairman: GEORGE E. BRANDOW, Pennsylvania State University

Papers: Wheat and Farm Policy
JOHN A. SCHNITTKER, Kansas State University

The Problem-Multiplier Effect of Wheat Legislation
HELEN C. FARNSWORTH, Food Research Institute, Stanford University

Discussants: J. HOWARD CRAVEN, Bank of America
L. E. FOURAKER, Pennsylvania State University
CALVIN B. HOOVER, Duke University

6:30 P.M. Dinner Meeting of AFEA Members
Speaker: JOHN KENNETH GAILBRAITH, Harvard University
Agriculture in an Affluent Society

Friday, December 30

Morning Session (Joint with American Marketing Association)
INTERRELATIONS OF FOOD MARKETING AND FARMING IN THE AMERICAN ECONOMY
Chairman: GEORGE L. MEHREN, University of California
Papers: Economic Interdependence of Marketing and Producing Firms in American Agriculture
CHESTER O. MCCORKLE, JR., University of California, Davis
Requirements of Consumers, Distributors, and Processors That Are Important to Farmers
HENRY B. ARTHUR, Harvard University
Discussants: W. E. HAMILTON, American Farm Bureau Federation
WROE ALDERSON, University of Pennsylvania

Afternoon Session (Joint with American Statistical Association)
HOW WELL DO ECONOMIC INDICATORS INDICATE WHAT IS HAPPENING IN THE MAJOR SECTORS OF THE ECONOMY?
Chairman: NATHAN KOFFSKY, United States Department of Agriculture
Papers: Economic Indicators for Agriculture
LAURENCE L. BOGER, Michigan State University
Economic Indicators for Labor
STANLEY RUTTENBURG, AFL-CIO
Economic Indicators for Industry
MARTIN GAINSBRUGH, National Industrial Conference Board
Discussants: O. V. WELLS, Agricultural Marketing Service
EWAN CLAGUE, Bureau of Labor Statistics
LOUIS PARADISO, Department of Commerce

THE AMERICAN FARM ECONOMIC ASSOCIATION AWARDS FOR RESEARCH IN AGRICULTURAL ECONOMICS, 1961

To recognize and encourage meritorious research in agricultural economics, seven awards of $250 each will be presented in 1961 by the American Farm Economic Association. In addition, three awards of $100 each will be presented for master's degree theses.

Selection for the awards will be made from published research, Ph.D. theses, and M.S. theses submitted for consideration in accordance with the procedures outlined below. No one may receive an award in the same category more than once every three years.

Awards for Published Research

1. Three $250 awards, each in a different field of agricultural economics, will be made for publications including bulletins, articles, pamphlets and monographs (textbooks are ineligible) classified in the following categories:

(a) Farm management and production economics
(b) Agricultural marketing
(c) Agricultural prices
(d) Agricultural finance
(e) Land and water economics and conservation
(f) Theory and Methodology
(g) Agricultural policy
(h) General agricultural economics

2. Persons submitting items should indicate the field in which they believe the reports should be classified.

3. Selections will be made from published research bearing the publication date of 1960.

4. Eligible recipients must be less than 41 years of age at the time of publication.

5. Members of the Awards Subcommittee for Published Research will not be eligible to submit papers of their own.

6. Each published report may receive only one award presented by the American Farm Economic Association in 1961. An entry may, however, be entered in more than one of the following categories: (a) Best article appearing in the *Journal of Farm Economics;* (b) Published research; and (c) Ph.D. thesis.

7. Nine copies are requested of each publication submitted for consideration. Fewer copies will be accepted in such cases as articles appearing in national journals available to the judges. In no event should less than three copies be sent.

8. The Awards Subcommittee for Published Research will consist of nine persons, in addition to the Chairman, representing the various designated fields. The members of the Subcommittee, all of whom will serve as judges, are:

K. L. Bachman, Agricultural Marketing Service
Arval Erickson, Oscar Mayer & Company
Stanley K. Seaver, University of Connecticut
Rex F. Daly, Agricultural Marketing Service
Donald C. Horton, Bureau of the Budget
Howard E. Conklin, Cornell University

Harold F. Breimyer, Council of Economic Advisors
Donald R. Kaldor, Iowa State University
Lee R. Martin, University of Arkansas

9. Publications should be sent directly to the Chairman of this Subcommittee, George K. Brinegar, Department of Agricultural Economics, University of Illinois, Urbana, Illinois, *on or before March 15, 1961.*

AWARDS FOR PH.D. THESES

1. Three $250 awards will be made for theses prepared by candidates for the Ph.D. degree in any department of Economics or Agricultural Economics.

2. An entry must be submitted by the head of the department to which the thesis was presented in partial fulfillment of requirements for a degree. A department may submit one thesis for each eight Ph.D. theses or fraction thereof presented to a graduate school faculty in 1960.

3. Selection will be made from theses approved in final form by the student's advisory committee during the calendar year 1960 provided the candidate has met all other formal requirements for the Ph.D. degree.

4. A published thesis may be entered in both the published research and thesis classes but will be eligible for only one award. Although a published thesis is acceptable, a copy of the thesis as submitted to the graduate faculty should be sent whenever possible.

5. Only one copy of an unpublished thesis will need to be sent to the Committee Chairman for consideration; however, if two or three are available it will expedite the judging. All copies will be returned after they have been read by the judges.

6. The Awards Subcommittee for Ph.D. Theses will consist of three persons, in addition to the Chairman. These three persons, all of whom will serve as judges are:

Norman Collins, University of California
Vernon Ruttan, Purdue University
W. F. Mueller, University of Wisconsin

7. Theses should be sent directly to the Chairman of this Subcommittee, Geoffrey S. Shepherd, Department of Agricultural Economics, Iowa State University, Ames, Iowa, *on or before March 15, 1961.*

AWARD FOR BEST ARTICLE IN JOURNAL OF FARM ECONOMICS

As has been the practice for a number of years, the Editors and Editorial Council of the *Journal of Farm Economics* will again choose the most outstanding article published in the *Journal* during the preceding calendar year (in this instance 1960). The amount of this award is $250.

AWARDS FOR M.S. THESES

1. Three $100 awards will be made for theses prepared by candidates for the M.S. degree in any department engaged in training agricultural economists at the Master's degree level.

2. An entry must be submitted by the head of the department to which the thesis was submitted in partial fulfillment of requirements for a degree. No department may submit more than one thesis for consideration.

3. Selection will be made from theses approved in final form by the student's advisory committee during the calendar year 1960 provided the candidate has met all other formal requirements for the Master's degree.

4. Only one standard typewritten copy as submitted to the graduate faculty need be sent to the Committee Chairman for consideration, but if two copies can be sent, it will be appreciated by the Committee. All copies will be returned after the Committee has completed its work.

5. The Awards Subcommittee for M.S. theses will consist of three persons in addition to the Chairman. These three persons, all of whom will serve as judges are:

G. Burton Wood, Oregon State College
James T. Bonnen, Michigan State University
Robert G. F. Spitze, University of Tennessee

6. Theses should be sent directly to William D. Toussaint, Chairman of this Subcommittee, Department of Agricultural Economics, University of North Carolina, Raleigh, North Carolina, *on or before March 15, 1961.*

Announcements of the 1961 awards will be made at the 1961 annual meeting of the American Farm Economic Association. Names of the recipients of the 1960 awards will appear in the Proceedings Issue of the *Journal of Farm Economics.*

These awards are financed in part from funds donated by persons and firms interested in advancing research and scholarship in Agricultural Economics. The funds and programs are administered by the American Farm Economic Association. General inquiries, and requests for additional copies of this announcement, should be directed to the Chairman of the Awards Committee, Leonard F. Miller, Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma.

ELEVENTH INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS

Cuernavaca, Mexico, August 19-30, 1961

The eleventh International Conference of Agricultural Economists will be held in Cuernavaca, Mexico, beginning on Saturday, August 19, and ending on Wednesday, August 30. Cuernavaca is the capital of the State of Morelos and is located about 75 kilometers (46 miles) from Mexico City.

The climate in Cuernavaca will be pleasant, with the highest temperature at noon about 20°C (68°F). During the last twenty-five years the maximum temperature at noon in August has been 32.7°C (90.86°F) with a minimum of 14.5°C (58.10°F).

Accommodations will be provided in the Casino de la Selva Hotel, where the meals will also be served. Room and board will average approximately $8.00 per day. The official conference sessions will begin on Sunday, August 20, in the hotel auditorium, which can accommodate about 700 people.

Program

The theme of the Conference will be: The Role of Agriculture in Economic Development.

Subjects will include:

1. Panel on host country
2. The concept of economic growth
3. Measuring economic growth and agriculture's contribution thereto
4. Role of agriculture in economic development—country experiences: (a) Nigeria, (b) Brazil, (c) Burma, (d) Ireland, (e) West Germany
5. Indigenous and foreign investment in agricultural development
6. Environmental conditions for agricultural development: (a) educational, (b) sociological, (c) institutional, (d) health and nutrition
7. Developments in patterns of farm units: (a) techniques for new lands and new settlements, (b) consolidating farms and improving layouts, (c) experience with large-scale farms
8. Market structure for agricultural development
9. The agricultural economist and his tools: (a) research methods, (b) development extension work
10. Using research findings in policy issues

There will be a series of discussion groups so that all attending will have an opportunity to participate. These will be organized for detailed consideration of a number of topics such as: (a) research in farm management; (b) research in marketing; (c) land problems; (d) farm credit; (e) cooperation; (f) rural development; (g) farm price policy; (h) food and nutrition programs; (i) extension and advisory work; and (j) teaching of agricultural economics.

Two tours are planned during the Conference; the first will visit dairy farms, and the pyramids and the College of Agriculture at Chipango; the second will include a visit to cooperative sugar mills, to the archeological sites near Cuernavaca, and to Taxco. Ample time will be allowed for individually planned trips to Mexico City.

Following the Conference three tours, to run concurrently, will be available

to participants: (1) A six-day tour to the irrigated northwest section of Mexico, to be made by plane and bus, at a cost of $100. About 60 persons could be accommodated. This section of the country provides most of the agricultural products for export. (2) An eight-day tour in the "Bajio," the grain producing central plateau area, to be made by bus at a cost of $75. It is estimated about 200 persons would want to take this tour. (3) A five-day tour to tropical Papaloapan, to the east of Mexico City, to visit the area which produces coffee, pineapple, sugar cane, and vanilla. This tour would be made by bus and would cost $40. About 100 persons could be accommodated. All tours would begin in Cuernavaca and end in Mexico City. Each bus will be provided with an experienced guide and a technician, both speaking English and Spanish.

Summer Course at Ohio State University

A few planning to attend the Conference may be interested to know that the U. S. International Cooperation Administration is offering financial assistance to individuals in countries where special ICA activities are under way to attend a special three-week course at the Ohio State University, the AFEA meeting at Fort Collins, Colorado, the meeting of the ICAE, and a week's evaluation program in Washington following the Conference. These grants will be available to a limited number of people involved in development programs in their respective countries, but including University people where they are active in problems of agricultural development.

The three-week course at Ohio State University, Columbus, Ohio, will be held from July 24 to August 11 and will cover problems encountered in less-developed countries and the application of economic principles to their solution; selection and defining of problems for research and methods of collecting and analyzing data; research methodology; farm production; and marketing prices. These courses are also open to other individuals, who may apply directly to: Dr. Mervin G. Smith, Department of Agricultural Economics, Ohio State University, Columbus, Ohio. Application can be made through the Ministry of Agriculture in cooperating countries.

Summer Meeting, American Farm Economic Association

The meeting of the American Farm Economic Association, at Fort Collins, Colorado, will begin two days after the close of the short courses. Sessions will begin August 13 and close August 16. Any participants en route to the ICAE meeting are welcome to attend the American Farm Economic Association meeting.

Inquiries regarding the ICAE meeting should be directed to the Secretary-Treasurer, Joseph Ackerman, at the Farm Foundation, 600 South Michigan Avenue, Chicago 5, Illinois.